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A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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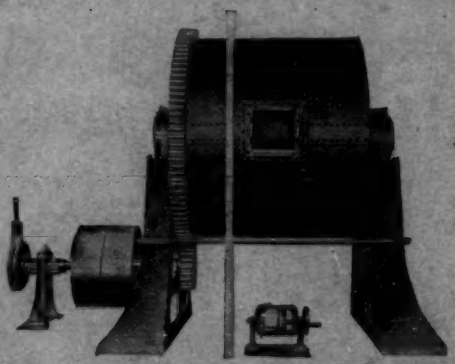

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Vol. 4 **March, 1921** **No. 3**

EDITORIAL

PRACTICAL APPLICATION OUR PRESENT NEED

I do not wish to discourage any man or set of men from undertaking new discoveries or improvement methods, however slight the chance of adding greatly to present knowledge. Many dollars have been wasted in vain attempts to solve problems of which we are still ignorant but out of all such effort some progress will be made. Men who are willing to contribute of their means in efforts bearing but little promise of results are philanthropists. But nevertheless those who are engaged in the business for profit should be first persuaded to take advantage of what they now have.

The clay manufacturing industry is not so much in need of discovery as it is in need of grasping opportunity.

A recent editorial in a clay trade journal calls loudly for a reduction of costs by means of more technical investigation. In the same issue is an unanswered appeal from a subscriber for information as to how to remove lime pebbles from a common brick clay. On another page is the announcement of the departure from the industry of a prominent technical investigator. The three items answer pretty clearly the question "What's the matter with the brick industry?" A mania for technical information of no value unless it is applied. Inefficiency in the distribution of the most ordinary information. The departure from the industry of the very men and the only men capable of applying the information already available or to be yet acquired.

The first and foremost need of the clay industry is not so much

new technical information, as it is the ability and willingness to apply that which we already have. In other words, we need common sense engineering in the manufacture of brick and tile and a technically trained personnel on each individual plant instead of in a distant laboratory. The manufacture of brick and tile has, in the opinion of many, reached a critical point in its development. The public's need for such ware is undeniable but, in order to serve to the utmost, qualities must be improved and costs reduced.

Just as it would be extremely foolish to delay action until a steam launch were available to save a drowning man twenty feet from shore, with a row boat, a coil of rope and a life preserver right at hand, to say nothing of a half dozen good swimmers, so would it, in my opinion, be foolish to undertake an elaborate program of experiment like that involved in an experimental plant or an association laboratory and meanwhile make no attempt to get better results from present equipment or refuse to replace obsolete methods and equipment with that which is already available, and an obvious improvement and cost reducer. There are hundreds of hand fed dry pans, hundreds of dust bins that must be shoveled out. Hundreds of choking elevators too small for the work required. Thousands of steam and water leaks, miles of uninsulated steam lines, thousands of slide valve engines, scaly boilers and unpainted buildings, for none of which is the laboratory responsible or a curative. The spectacular, unusual saving is more attractive but in the clay industry, unfortunately, the spectacular things have never gotten anywhere and of the sponsors for the spectacular, revolutionizing plants which have been put across, we may say, like the knights of old "Their bones are dust. Their good swords rust. Their souls are with the saints we trust." But in their path is also rusting machinery and discouraged men.

The industry is essentially one of small investment and comparatively widely scattered units. Each plant, or at best, each district deals with a material and often a product peculiar to itself and each plant organization must develop an ability to apply good mechanical engineering and general ceramic information to the local situation. The common sense application of good

mechanics, sound construction and known ceramic technology can easily reduce the cost of clay ware manufacture twenty-five per cent.

In the matter of burning, for instance, why not shorten the burning time and get all the economy possible out of our present periodic kilns as well as experiment with other types. Each and every plant in the country can improve its burning by a more intelligent use of pyrometer, draft gauges, CO_2 recorders, or flue gas analysis. Many plants are using pyrometers, yes, but for what purposes? To regulate the burning? Not at all. They are in the office under lock and key and are used to discover if the night firemen sleep on the job. Draft gauges have been bought but, because of inability to use them to any advantage, have been discarded. Gas analyses have been made, during one burn, and no application made of the results.

I have visited some of the largest and some of the smallest clay working plants of the country, in sixteen different states, and I have yet to find a pyrometer, a draft gauge, an Orsatt apparatus or a CO_2 recorder on one and the same plant at the same time. I have never seen a hygrometer at work on any plant and only twice an anemometer, and I used both of them myself. I will venture the opinion that on more than half the plants of the country the above instruments could not be identified. Neither have I ever known a plant to buy its coal on a guaranteed heat unit basis, yet is has been established beyond question that fuel economy of any furnace depends upon the factors measured only by these instruments and the heating value of fuel depends upon the heat units it will produce.

Other consumers of large amounts of fuel find it profitable to employ men who are able to check up the fuel used and to get value for every dollar expended, why not the clay industry, which is the third largest consumer of coal and the greatest waster?

Another item of importance, not so easily corrected in present kilns, but possible of being cared for in future construction and possible of yielding a large return if cared for is the waste by radiation. Even clay manufacturers cover boilers and steam lines. Few other industries neglect it, but brick kilns exposed to wind, rain and zero temperatures are seldom insulated. Years

ago it was shown that the radiation losses of the average kiln is around twenty per cent. Aside from neglect to insulate, there is a serious loss due to pure shiftlessness. Kiln crowns during a burn are so hot that one can not walk upon them with comfort or safety to an ordinary shoe, but little attempt is made to stop the waste of heat. On many plants, if the crown holes are sufficiently covered to keep out most of the rain, to say nothing of keeping heat in, it is enough. On many plants it is the custom to light fires in a kiln being set when it rains to prevent the water from spoiling the ware. Can you expect to keep heat in a structure that won't keep water out?

Kiln repairs are often so neglected, especially on multiple stack kilns, that the draft through the kiln wall is stronger than through the flues and much of the developed heat never gets into the kiln at all.

With such management in the use of a simple, round, down draft kiln—and there are other abuses I have not mentioned—isn't it rather foolish to talk about spending $150,000 to $200,000 on an experimental tunnel kiln which, if installed on the average plant, would be subject to abuses and incompetence, instead of the intelligent handling it would require for successful operation.

I have in mind one continuous kiln which has never been a marked success but I was told in all seriousness that the burner changed the direction of the draft because a vine grows around a stump in that direction and he knew it would work better for that reason. I remember also a conversation with a paving brick manufacturer in which he stated that on a certain plant, so long as they kept a young fellow making gas analyses and watching the draft, they obtained wonderful fuel economy but, of course, could not keep him there all the time and the burners soon went back to the old methods. The question is WHY NOT KEEP THE YOUNG FELLOW THERE ALL THE TIME?

There have been many instances of loss incurred by adopting, without adapting, the processes and appliances of one plant by another. What each plant needs is the brain that can adapt. It can be had in the employment of technical men on the plants at salaries sufficient to keep them there. It can not be had any other way and each plant, in my judgment, can and must work

out its own salvation. It must put capital into brains and equipment instead of expense into common labor. Many operations can be carried on mechanically at very substantial savings. Transport of raw material, for instance, by man power and wheelbarrows should be stopped, whether the handling be ten feet or one hundred. The unloading of coal from railroad cars by hand shoveling and its distribution by wheelbarrow is another economic waste. But in a survey of some twenty odd plants in the Canton district within the past six months, I found but three using mechanical dry pan feeders and saw but one coal unloader. And with such conditions, we are asked to pile up technical information. May I ask WHAT FOR?

The results of any set of experiments can only be applied in a general way to conditions which are similar. Uniformity in a natural clay mixture is an utterly unattainable condition, even for any one given plant. Why not recognize this fact and stop talking about applying any given set of rules for die construction for instance, to the entire industry. Each new car of clay on every plant is more or less of a problem and an experiment. Who can tell whether it will grind, screen, pug, form, dry, burn or ship in any way similar to the last car mined. I admit this is extreme, but I recall a paper read in New York four years ago in which the entirely different characteristics of the chemical composition as disclosed by the microscope of two samples of paving block were very carefully described. The author stated that the two slides in question were taken one-fourth inch apart from the same paving block. For men to talk seriously of standardizing such materials in an experimental plant or anywhere else sounds rather foolish, doesn't it?

Lamination is a favorite subject for study. Two types are recognized—auger and die. To standardize the auger or the die on an experimental plant would mean to meet on that plant the varying clay and the varying workmanship of every plant in the country. It is a big job on any one plant, to say nothing of a hundred. I know of experiments extending over a period of nearly four years undertaken for the purpose of perfecting a die to run a column one inch thick and six inches wide, which was finally run with fair success. The same type of die was lately

used to run a column $1^1/_2$ inches thick and nine inches wide and it failed to the tune of more than ten thousand dollars but responsibility for the failure was placed on the burner, who is the favorite goat for a great many unexplained losses.

I have seen both hollow ware and brick columns run perfectly for ten, twenty, perhaps a hundred feet, then suddenly rag on one, two, three or four corners, run ragged for a few feet, heal, and go on again perfectly. What caused it? Nobody knows. Can you hope to eliminate, in an experimental plant, all the variables that might have caused it, so that you can furnish even one other plant one die that, without adjustment, positively will not rag a corner or show lamination from the time it goes on the machine until it comes off? If that can not be done in the experimental plant, then, so far as dies are concerned, it would be a failure and a positive waste of money. Better put a man at the machine of the average plant who has the brain and training to think—a technical man, if you will, who can design, balance and lubricate a new die for that particular material with as little lost time as possible. His results will be more positive after three months observation of a particular plant's material, equipment and personnel, than those of the experimental plant in a central location could possibly be in five years. It can not be hoped to put all machinery manufacturers but one out of business, neither can it be hoped to persuade the others that any one's design of machine is best, and all dies, all augers and all plungers laminate to a greater or less degree and all clays laminate to a greater or less degree when moved through a die by pressure. It is immaterial how that pressure is exerted, whether by auger or plunger. If the slippage of the clay particles over one another does not form bridges and gaps in the structure, the lamination may not be visible. Few plants but suffer from extreme lamination at intervals and few escape making a practically perfect product occasionally, but if the variable which brings about either of the above conditions on any individual plant can not be positively spotted in from ten to twenty-five years operation, how can one hope to locate it in an experimental plant, using perhaps enough of each of several kinds of raw material to run at capacity for half a day—or as any other plant, on a particular material, continuously.

If standardized on a given material, the plant would be worth to the industry just what Tom Jones or Bill Smith's plant is worth. It would have in it expert men in each department who could be hired away and who would run the same chance of failure on a new material that Tom or Bill's men now run. New men would have to be trained just as they have to be in Tom's plant or yours.

Each process on the average plant is subject to improvement, simple improvements too and not involving heavy outlays. Going back for a moment to the mechanical dry pan feeder, a device that has been on the market about three years. Many plants are still dumping material crushed or otherwise on to a floor in front of the dry pans to be shoveled into the pans by one or more men, depending upon the distance and amount. By the use of a feeder the shoveling is eliminated and more than one man for half a dozen pans could not possibly be kept busy.

Coal unloaders are not expensive to install or to operate, and if it is good business to unload fifty tons of coal a day by hand shovel, why would it not be good business to throw away the engine or motor and put enough laborers in a tread mill or on a crank to run the whole plant that way? MARION W. BLAIR.

TO AUTHORS OF PAPERS

The attention of authors of papers intended for publication in the JOURNAL is directed to the new regulations governing the preparation of author's abstracts, appearing on page 257 of this number. All manuscripts submitted to the JOURNAL should in future be accompanied by an abstract prepared in accordance with the directions given.

A STUDY OF THE HEATING AND COOLING CURVES OF JAPANESE KAOLINITE

By S. Satoh

ABSTRACT

Effect of heating Japanese kaolinite at 100° to 1400° C for 3 to 4 hours.—Ignition loss of weight was found to occur chiefly between 400° and 600°C, the rate of increase per degree reaching a maximum at about 460°C. Changes of microstructure were observed at 600°, 900–1000°, 1250–1300° and at 1400°C, when sillimanite began to develop.

Heating and cooling curves for Japanese kaolinite, to 1400°C.—A differential method was used with quartz sand as the comparison substance. In addition to the known reactions: (1) an endothermic from 450° to 700°, and (2) an exothermic near 950°, (3) an exothermic change between 1200° and 1300° was discovered, and it was observed that the endothermic reaction seems to include two periods of heat absorption, (1a) 450° to 650° and (1b) 650° to 700°. **In explanation,** the author suggests that 1a is due to dehydration, 1b to dissociation of kaolinite into free alumina and free silica, 2 to a polymerization of the alumia and 3 to the formation of amorphous sillimanite. In the discussion, E. W. Washburn calls attention to the fact that the author has neglected the endothermic reaction of quartz at 575°C and suggests that some of his conclusions are therefore erroneous.

Heating and cooling curves for alumina obtained from the nitrate, hydroxide and sulfate by calcination are given in figure 6. Exothermic reactions which are ascribed by the author to polymerization of alumia occur at 800° to 900° and at 1100° to 1200° instead of at 950° and at 1250° as in the case of kaolinite.

1. Introduction.—The endothermal and the exothermal reactions shown by kaolinite on heating have been examined by Le Chatelier,[1] Ashley,[2] Rieke,[3] Brown and Montgomery,[4] and Mellor and Holdcroft.[5]

While the details of the experiments carried out by these different investigators varied somewhat, the aim of all was to find the temperature of, and the range of, dehydration.

[1] *Bull. Soc. Min.*, **10,** 307 (1887).
[2] *Jour. Ind. Eng. Chem.*, **3,** 91 (1910).
[3] *Sprechsaal*, **44,** 637 (1916).
[4] U. S. Bur. Stand., *Tech. Pap.* No. **21,** (1913).
[5] *Trans. Eng. Ceram. Soc.*, **9,** 94 (1911); also **10,** 169 (1912).

Mellor and Holdcroft furthermore from their results concluded that Groth's[1] formula for kaolinite was probably the correct one, although several others have been suggested.[2]

In the present paper the writer presents the results of a study by a more accurate method, of the thermal changes produced in Japanese kaolinite, including a microscopic study of the change in structure on heating. The results are made public by permission of the Tokyo Electric Company, Ltd.

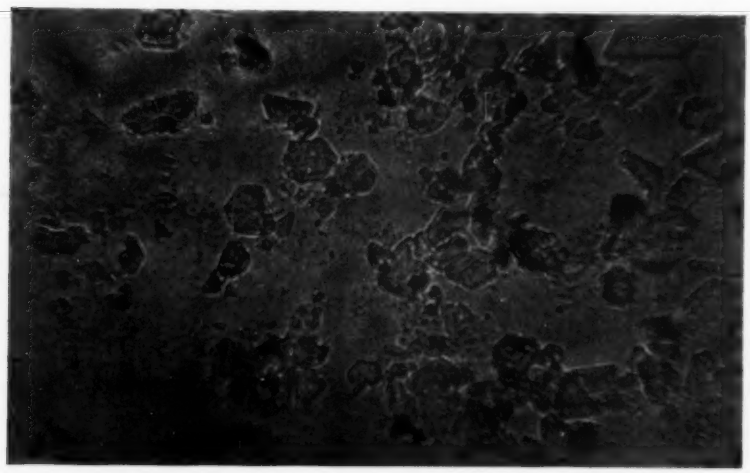


FIG. 1.—Unburned kaolinite from Azushiomura, Japan. Mag. 340.

2. Chemical Analysis and Microscopical Observation.—Crystalline kaolinite is rare in Japan, but recently a small quantity of it, obtained at Azushiomura in Fukushima province, was kindly given me for study by Mr. I. Asai, lecturer in the Tokyo Higher Technical School. A chemical analysis made in the laboratory of the Tokyo Electric Company, Ltd. is as follows:

[1] *Tabellarische Uebersicht der Mineralien*, **1898**, p. 137.,

[2] Vernadsky, *Z. Kryst. u. Min.*, **34**, 37 (1901); Haushofer, *Die Constitution der Naturalien*, p. 26, Braunschweig, **1874**; Hundeshagen, *Z. angew. Chem.*, **21**, 2454 (1908); Siemond, *Trans. Chem. Soc.*, **83**, 1449 (1903); Clarke, U. S. Geol. Surv., *Bull.* **125**, p. 32, (1895); W. and D. Asch, *Die Silicate in chemischer und technischer Beziehung*.

	Per cent		Per cent
SiO_2	45.01	MgO	trace
Al_2O_3	41.18	Alkali Oxides	0.86
Fe_2O_3	0.30	Loss on ignition	12.22
CaO	.72		

Microscopical examination showed that the sample, though contaminated with foreign materials, contains hexagonal plate like crystals (Fig. 1) which are undoubtedly kaolinite.

The material was heated for 4 hours in an electric furnace at each of the following temperatures, *i. e.*, 110°, 200°, 300°,

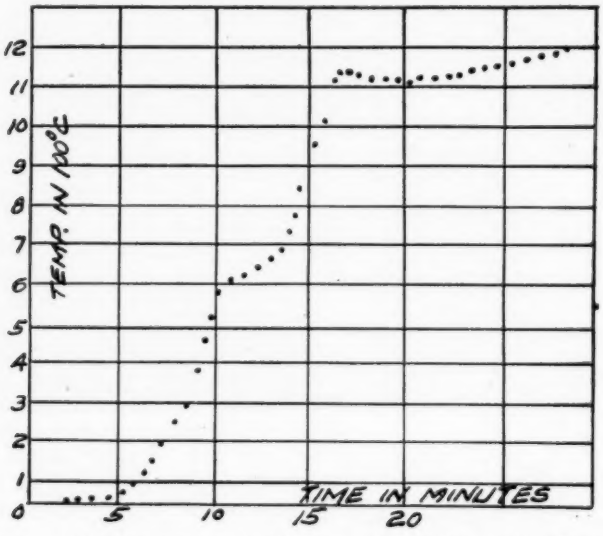


FIG. 2—Heating curve of kaolinite. After Mellor and Holdcroft.

400°, 500°, 600°, 700°, 800°, 900°, 1000°, 1050°, 1100°, 1150°, 1200°, 1250°, 1300°, 1350°, and 1400°C, its change of structure being examined microscopically after each heating.

The temperature of the electric furnace was measured with a precision voltmeter and a thermocouple, using a copper-constantan junction for low temperatures, and a platinum-platinum rhodium junction for high temperatures. At the lower temperatures the kaolinite tested showed many minute particles optically anisotropic. Each individual crystal gradually cracks

and shows a loss in transparency with rising temperature. A molecular disturbance first takes place near 600°C, and another between 900° and 1000°C. After the second disturbance, the material appears to be isotropic. It was furthermore noticed that between 1250° and 1300°C, the texture becomes granular and the grains appear to have a higher reflecting power. Sillimanite begins to develop near 1400°C. It seems that the structural change between 1250°–1300°C is common to all fire-clays, and without it sillimanite crystals are never developed.

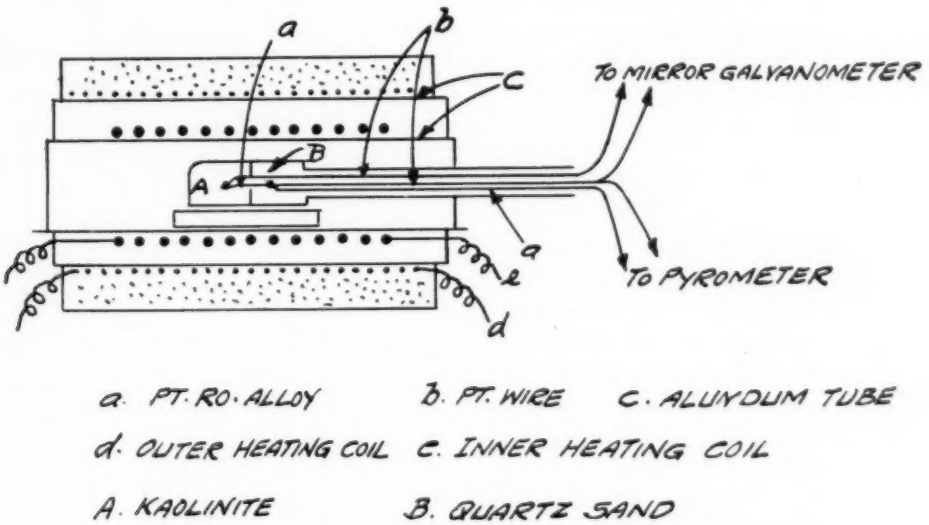


FIG. 3—Diagram of furnace and thermocouple set-up.

3. **Endothermal and Exothermal Reactions.**—To test these characteristics, I used at first the method employed by Mellor and Holdcroft, and obtained a heating curve, resembling theirs, which is shown in figure 2. The temperature at which the endo- and exothermal changes took place was rather indefinite and so I finally used the differential method, illustrated in figure 3. The apparatus consisted of a hollow cylinder of highly refractory material, 1 inch long and $^1/_2$ inch in diameter, which was divided into two chambers, A and B, by a wall in the middle.

The differential thermo junctions were placed in the middle

of the tube, one in front of the wall and the other behind it. The differential junctions were so constructed, that two long pieces of platinum wire were connected by a short piece of platinum-rhodium wire, *a*. These two joints were placed exactly in the middle part of chambers A and B, and the other ends of the platinum wires were led to a glavanometer of Siemens and Halske make. In addition a long platinum-rhodium wire was forked from one of the joints to form an ordinary thermocouple with one of the platinum arms of the differential junction. The ends of this thermocouple were connected with a millivoltmeter

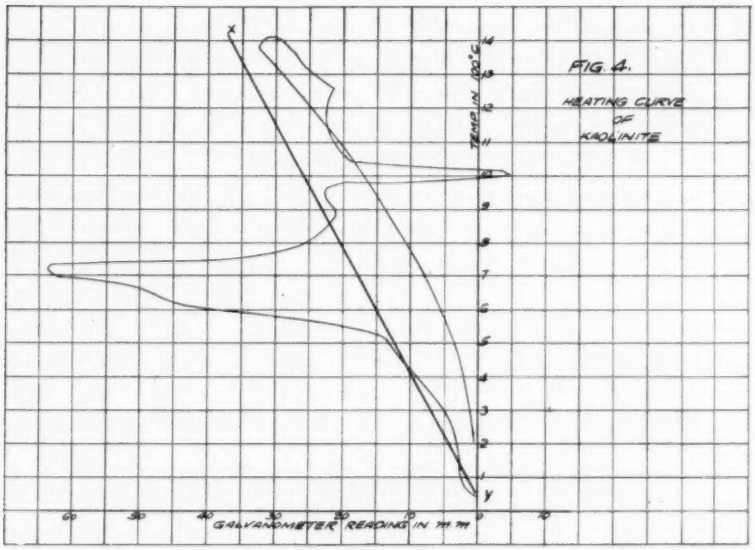


FIG. 4.

attached to a Siemen and Halske pyrometer. The chamber, A, was packed with Kaolinite powder, and the chamber, B, filled with calcined quartz sand. The temperature difference between the kaolinite and the quartz sand was observed with a mirror galvanometer connected to the differential junction; while the temperature of the quartz sand was simultaneously measured with the pyrometer. The sensitiveness of the differential thermojunctions was first determined and found to be 2 mm. scale divisions per degree of temperature.

Figure 4 represents the heating curve obtained by this method, the deflection of the mirror galvanometer and the temperature of the quartz sand being taken as the coördinates. The curve deviates as a whole to the left side of the ordinate axis, due to the slight deviation from the true position where the refractory cylinder ought to be placed in the furnace. Evidently the curve shows that the temperature rises more quickly at B than at A (Fig. 3), the rate being represented by the line *xy* (Fig. 4) although there is no change in the specimen. The cylinder was always placed as nearly as possible in exactly the same position in the furnace but in spite of this precaution, it occasionally happened that the zero line fell to the right side of the axis. In other words, the curve parallels the line *xy*, whenever there is no change in the specimen, and for this reason the line *xy* will be called the "zero line."

There seems no doubt that some endothermal change is taking place in the specimen, whenever any point on the curve lies to the left of the zero line, and has a tangent at that point which makes some positive angle with the zero line. The angle will be designated as positive, if a line makes an angle in the counter clockwise direction from the zero line: On the other hand some exothermal change is taking place when the point in the curve lies to the right of the zero line, so that the tangent at that point makes a negative angle with the zero line according to the above convention. It is difficult to calculate the quantities of heat absorbed or generated from this curve alone for these exist many complicated factors affecting the physical condition of the specimen, such as heat conduction, the difference in the specific heat of the specimens, and that of the surrounding material,. etc., but, it is easier to determine the temperature of the endo- or exothermal reactions, from this type of curve than from that previously obtained by many other investigators.

A study of the curve given in figure 4 shows that there was heat absorption in the specimen up to 100°C followed by a faint evolution of heat up to 300°C. From 450° to 700°C there was a remarkable heat absorption, which corresponds to the range of dehydration and dissociation defined by Mellor and others. Considering this heat absorption in more detail

we see that the tangent to the curve makes a positive angle with the zero line above 450°C, its value increasing rapidly; after reaching a maximum at 600°C it decreases up to 650°C, while above 650°C it again increases up to 700°C. It is therefore clear, that there are two distinct periods of heat absorption, one of which ranges from 450°C to 650°C, the other from 650° to 700°C. An exothermal reaction is distinctly seen near 950°C, and another faint evolution of heat takes place between 1200°C and 1300°C. This exothermal reaction has not been noticed by other investigators.

The reactions mentioned above may be summarized as follows:

1. Heat absorption up to 100°C.
2. Weak heat evolution from 100°C to 300°C.
3. Heat absorption from 450°C to 650°C.
4. Heat absorption from 650°C to 700°C.
5. Heat evolution near 950°C.
6. Heat evolution between 1200° and 1300°C.

In this experiment, the error of temperature measurement did not exceed 30°C. The fact that the tangent to the curve makes a negative angle with the zero line means that although the temperature-difference between kaolinite and quartz is increasing positively, it is not certain that the specimen is undergoing some exothermal change. In the same way the fact that the tangent to the curve makes a positive angle with the zero line, does not definitely mean that the specimen is absorbing heat. Because, if a temperature difference is once found between the specimen and the quartz sand as the result of the endo- and exothermal reactions, and afterward the reaction ceases, it is natural that by thermal conduction the temperatures of the two parts tend to equalize, and as a natural consequence the above phenomena will take place.

4. Discussion of the Results.—The heating curve represented in figure 4 is the most typical one of the results obtained from many experiments. We repeated many times the same experiments with the same substance, and sometimes raised the temperature of the specimen 1400°C within the comparatively short period of $1^1/_2$ hours, while at other times it took 6 hours to reach the same temperature. The results show that, without

regard to the period of heating, the heating curve was always of the same type, and the transition points of the specimen did not differ by more than 30°C.

In the heating curve (see Fig. 4), the heat absorption at the outset seems to be caused by the evaporation of the moisture contained in the specimen, as it takes place at 160°C. The second heat evolution near 350°C may be caused by the oxidation of the foreign minerals, which are easily oxidized, and the organic substances in the specimen. The third remarkable heat absorption is to be ascribed to the expulsion of the water of constitution.

The same kaolinite was heated 3 hours at a constant temperature in an electric resistance furnace, and the ignition loss at each temperature was measured. The results are represented on the following table:

Temperature	Ignition loss in per cent	Rate of ignition loss	Temperature	Ignition loss in per cent	Rate of ignition loss
200°C	0.43	0.28×10^{-2}	600°C	9.81	1.27×10^{-2}
300°C	.70	$.35 \times 10^{-2}$	650°C	10.45	0.49×10^{-2}
400°C	1.06	1.82×10^{-2}	700°C	.66	$.24 \times 10^{-2}$
450°C	.97	6.72×10^{-3}	750°C	.78	$.19 \times 10^{-2}$
500°C	5.33	$.13 \times 10^{-2}$	800°C	.84	.....
550°C	8.39	2.84×10^{-3}			

The rate column in the above table shows the ignition loss per one degree of temperature-rise at the corresponding temperature. The results are also plotted in figure 5, A and B. Curve A represents the relation between the firing temperature and the ignition loss; curve B represents the relation between the firing temperature and the rate of ignition loss per 1°C, the tangent curve of curve A. The ignition loss represents, probably the loss of the water of constitution in the case of comparatively pure kaolinite.

Let us consider once more the third heat absorption, which starts from 450°C and ends near 650°C; the feature of the curve agrees exactly with that of the curve B in figure 5. It may therefore be supposed that the endothermal reaction between 450°C and 650°C may be ascribed to the expulsion of water. Moreover, this fact means that the heat absorption from 650°C

to 700°C would be produced by another cause than the dehydration; because it is absurd to assume that the heat absorption is again increasing after 650°C, for the rate of ignition loss at that temperature has already diminished to 2×10^{-2} per cent as seen in figure 5 B, and apparently there is no sign of increase in the rate. We can not definitely state the true cause of the endothermal reaction from 650°C to 700°C, but it seems probable that the kaolinite breaks up into free allumina and free silica above 650°C, while Mellor and Holdcroft thought the dissociation took place in the neighborhood of 500°C. If we carefully examine the results of their experiments on density, hygroscopicity and solubility in acid, the characters of kaolinite above 650°C, but not from 500°C, seem to coincide with those of alumina obtained by the calcination of aluminum nitrate. The inconsistency of the above supposition as regards the nature of the substances at the temperature below 650°C will be briefly discussed later. The change may be expressed by means of chemical symbols, in the following manner:

$$H_4Si_2Al_2O_9 \longrightarrow Si_2Al_2O_7 + 2H_2O \text{ at } 500°C$$
$$\text{and } Si_2Al_2O_7 \longrightarrow Al_2O_3 + 2SiO_2 \quad \text{at } 650°C$$

It may be supposed from figure 5, A, that the OH group in kaolinite must be combined symmetrically with aluminium atoms or with silicon atoms.

The fifth exothermal reaction took place near 950°C. As it is difficult to determine by the old method the beginning of the reaction, several different temperatures have been found by previous investigators; Le Chatelier and Ashley assumed the point to be at 925°C. Mellor and Holdcroft compared the behavior of kaolinite with that of alumina prepared from aluminum nitrate, and allowing for the lag between material change and pyrometer indication, supposed that the exothermal change might happen at the temperature of 800°C, and that the alumina already dissociated from kaolinite at 500°C became polymerized at that temperature.

From our experiments, however, it seems probable that kaolinite, or its decomposition product, should change at somewhere near 950°C, and, as a consequence, heat evolution would take place. As mentioned above, there is not so much error in our

estimation of this temperature. On the other hand we observed from microscopical study that the optical properties of kaolinite change between 900°C and 1000°C.

5. The Polymerization of Alumina.—Figure 6 represents the heating curves of alumina obtained by the calcination of several aluminum salts, and figure 4 is included for convenient comparison. The alumina prepared by calcining aluminium nitrate for three

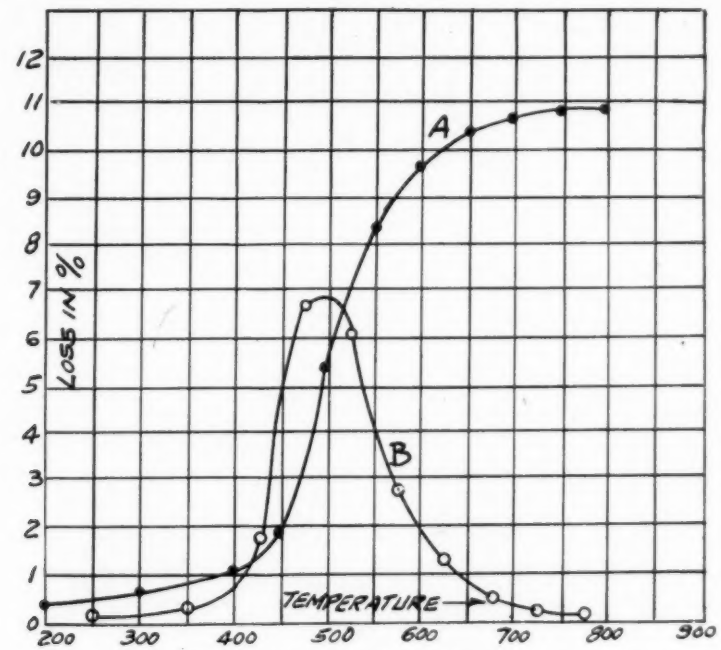


FIG. 5.—Loss in weight of kaolinite.

hours at 400°C (curve B) has two exothermal changes near 800°C and 1100°C. The alumnia obtained by heating the aluminium hydroxide prepared from aluminum alum shows a remarkable heat evolution near 1150°C (see curve C.). Calcined aluminium sulphate (see curve D) shows a remarkable heat absorption, which begins at 600°C and turns suddenly to heat evolution near 900°C; it shows another heat evolution near 1200°C. Thus we could not find the exothermal reaction

corresponding to that of kaolinite near 950°C in the curves of these samples of alumina. Nevertheless if we remember that with the free silica and with the free alumina produced by the dissociation of kaolinite, the molecules of the former were interposed between those of the latter, it is possible that the polymerization of the alumina at 800°C might be held back until 950°C; and for the same reason the exothermal change which happens at near 1100°C would be retarded to the same degree, and the exothermal changes of kaolinite near 950°C and 1250°

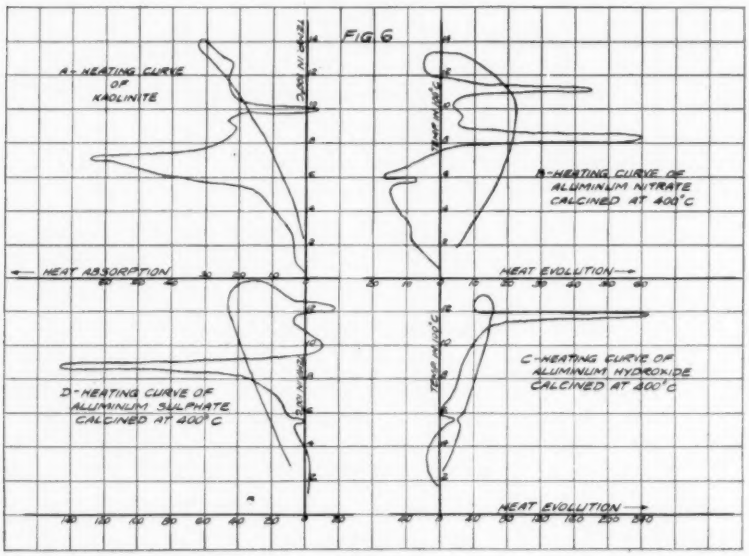


FIG 6
A- HEATING CURVE OF KAOLINITE
B- HEATING CURVE OF ALUMINIUM NITRATE CALCINED AT 400°C
C- HEATING CURVE OF ALUMINIUM HYDROXIDE CALCINED AT 400°C
D- HEATING CURVE OF ALUMINIUM SULPHATE CALCINED AT 400°C
HEAT ABSORPTION
HEAT EVOLUTION
HEAT EVOLUTION

FIG. 6.

C should therefore be explained as the polymerization of the alumina dissociated at lower temperatures. Such an explanation of the thermal changes would be favorable to the dissociation theory.

On the other hand, we know from microscopical observations, that kaolinite changes to an isotropic condition above 900°C, and its structure becomes granular and more refractive at a temperature between 1200°C and 1300°C. The former transformation may be taken as the polymerization of the alumina, and the latter as the formation of amorphous sillimanite by the recombination of dissociated free alumina and free silica.

The fact that curves A, B, and D of figure 6 show in common a weak exothermal change between 500° and 600°C, and that this change does not appear in the heating curve of kaolinite, confirms the hypothesis that kaolinite does not dissociate at temperatures below 600°C.

At any rate, the fact that at temperatures over 800°C there is no heat absorption, makes it difficult to explain the formation of sillimanite according to the anhydride theory for without the decomposition of the anhydride kaolinite, sillimanite could not be formed.

The graphical formula of kaolinite is not of great importance at present; but if we assume the formula of Groth as

$$(OH)_2 = Al - O - Si = O$$
$$\diagdown\!\diagup O$$
$$(OH)_2 = Al - O - Si = O$$

we do not encounter any difficulty in explaining the properties of kaolinite, and there is no necessity of assuming a more complicated formula.

It should be added that neither endothermal nor exothermal changes appeared in the heating curve of the quartz sand tested. It is the writer's intention to carry on similar experiments on many clay substances and chemicals.

In conclusion, I wish to express my hearty thanks to Mr. I. Asai who supplied the kaolinite for study, and to Messrs. Amada and Murai, of our laboratory, who carried out the experiments with real care and zeal.

DISCUSSION

E. W. WASHBURN: A careful study of the heating and cooling curves of typical clays by the differential method is highly desirable. In the present investigation the author has, however, made an unfortunate choice of a comparison substance, since quartz on heating undergoes an endothermal reaction at about 575°, changing from the α- to the β-form. The influence of this reaction is evident in all of the author's curves where points have been taken in this temperature region. The reaction is a reversible one, and its occurrence should appear both on the heating and on the cooling curve as shown in the author's figure 6 C, which

is the only figure in which both the heating and cooling curves contain observed points in the temperature region in question.

The author has interpreted the effect due to this change in the quartz in terms of some supposed change in his other material which leads him to a number of erroneous conclusions.

It would seem desirable in experiments of this character to subject the sample to a preliminary low temperature oxidation in pure oxygen (or ozone?), followed by the removal of adsorbed moisture by means of a high vacuum at low temperature.

THE EFFECT OF THE REPLACEMENT OF FREE SILICA BY ALUMINA AND ZIRCONIA IN ELECTRICAL PORCELAIN[1]

By Robert Twells, Jr., and C. C. Lin

ABSTRACT

Effect on electrical porcelain of the replacement of free silica by alumina and zirconia.—Since it had been suggested that free silica may be detrimental to the mechanical and the dielectric strengths of electrical porcelain, a series of sixteen batches was prepared in which various proportions of the free silica were replaced, weight for weight, by alumina, zirconia or combinations of both, and bars and disks, after burning at cone $8\frac{1}{2}$ to 9 or at cone 12, were tested for **shrinkage, transverse strength, impact strength, heat resistance, absorption of moisture and dye penetration.** The results show that resistance to sudden temperature changes can be greatly improved by substituting zirconia,—that the danger of overburning can be greatly decreased by substituting alumina and that the mechanical strengths can be increased by substituting either or both; but in the case of dielectric strength, no improvement was obtained by substituting for the free silica.

Object of the Investigation

It has been repeatedly stated by different investigators that the presence of free silica in an electrical porcelain body is a disadvantage. The actual harmfulness of the free silica seems to be difficult to prove. It seems necessary that there be some kind of a very refractory substance, not easily attacked by fluxes present in any vitrified body to act as a skeleton structure and thus prevent warpage. The statements of most writers on the subject seem to be based on the well-known isomorphous inversions of quartz. These inversions cause volume changes which undoubtedly set up strains in the body during its cooling period and which leave the body in a state of strain even after the insulator is in use. In Part III, Report 53 of the National Advisory Committee for Areonautics, Bleininger makes the statement "volume changes are unavoidable in all porcelains containing free quartz in all amounts, due to the inversions noted. In a good spark-plug porcelain, the quartz should be eliminated from

[1] Received Feb. 7, 1921.

the compound, and replaced by a substance not subject to these inversions."

Treischel,[1] however has advanced the theory that the dielectric failure of porcelains apparently free from mechanical defects was due chiefly to the piezo-electric effect of the free quartz in the porcelain. This theory seems to be a possible explanation of the dielectric failure of porcelains which can hardly be ascribed to the inversions of quartz.

In view of these objections to free silica, it seemed well to try the effect of substituting various refractory oxides for flint in an electrical porcelain body. In this way it was hoped to obtain a refractory skeleton which would prevent warpage in the body, but which would not show the defects ascribed to quartz.

Method of Attack

It was decided to replace the flint with ZrO_2 and Al_2O_3 as being the two oxides which, from their use in other bodies, seemed most suitable for this work. The next question seemed to be whether to make the substitution directly pound for pound or molecularly. Any attempt to introduce the ZrO_2 and Al_2O_3 in the standard body by use of its molecular formula leads at once to difficulties. It is self-evident that it would cause great changes in the molecular formula of the body to replace the free silica with alumina. Such a change in the molecular formula would be much greater than the corresponding change in the body since the alumina would not actually become dissolved in the eutectic melt surrounding it. The substitution of the ZrO_2 for the free SiO_2 would not produce such a radical change in the body formula since both compounds take the form RO_2.

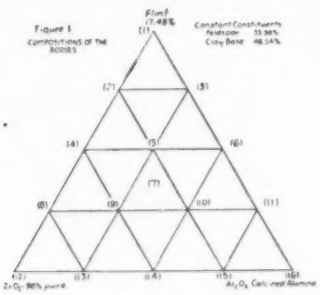
If we wish to assume that the ZrO_2 and Al_2O_3 will not be attacked by the eutectic melt surrounding them to a much greater extent than would the free silica, it seems logical to introduce them pound for pound to replace the latter. In this way the same amount of skeleton structure is introduced in each case.

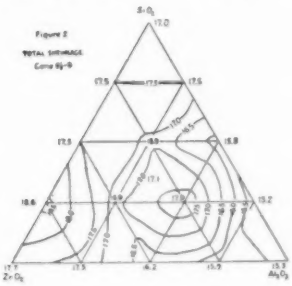
For the above reasons a simple triaxial substitution pound for pound was considered best. This is shown in figure 1.

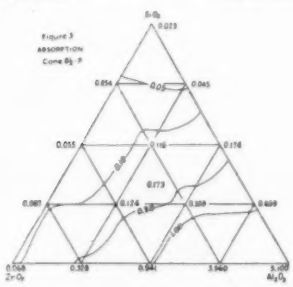
[1] Treischel, THIS JOURNAL, **2**, 96(1919).

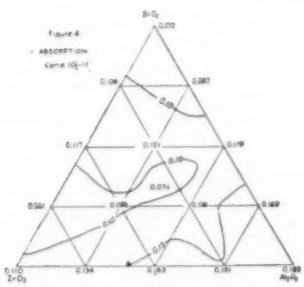
Preparation of the Bodies

A ten kilogram batch of each corner member was prepared, blunged for two hours in the laboratory blunger until a slip of uniform consistency was obtained, and lawned through a 100 mesh lawn into a porcelain jar. The water contents of the three corner slips were obtained and from them the intermediate members were made by blending in such a way that the slips representing each body contained about 1.8 kilograms of dry weight.









The slips were next allowed to stiffen in plaster molds, and were thoroughly wedged by hand before any trial pieces were made.

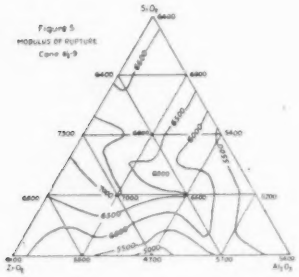
From each body the following test pieces were made:

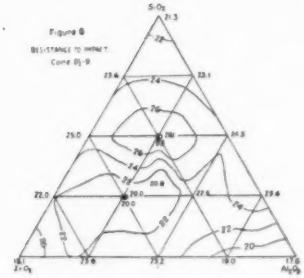
Trial Pieces

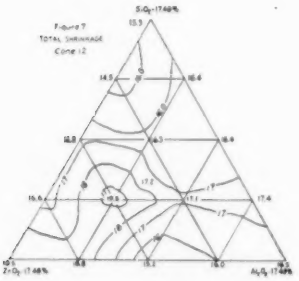
No. made	Test Pieces	Tests
9	Bars $4\frac{1}{2}'' \times \frac{1}{2}'' \times 1''$	Shrinkage
		Modulus of rupture
	(Broken bars)	Absorption
9	Discs $1\frac{3}{4}''$ dia. $\frac{1}{2}''$ thick	Resistance to temperature changes
9	Discs $1\frac{3}{4}''$ dia. $\frac{1}{2}''$ thick	Resistance to impact
	(Broken discs)	Dye penetration
2	Discs $1\frac{3}{4}''$ dia. $\frac{1}{2}''$ thick	Refired for absorption test.

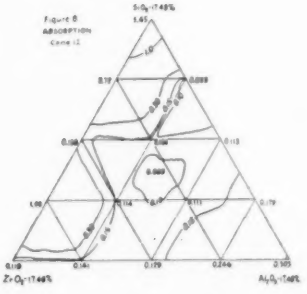
Drying and Firing

The test pieces dried thoroughly in air, so no attempt was made to dry them artificially. They were next placed in saggers with standard cones in each sagger, and fired in an up and down draft kiln. Half of the test pieces received a heat of cone $8^1/_2$–9, half received a heat of cone 12. Two discs from each body that had been fired at cone $8^1/_2$–9 were refired to cone $10^1/_2$ to give a better indication as to heat range.









Tests

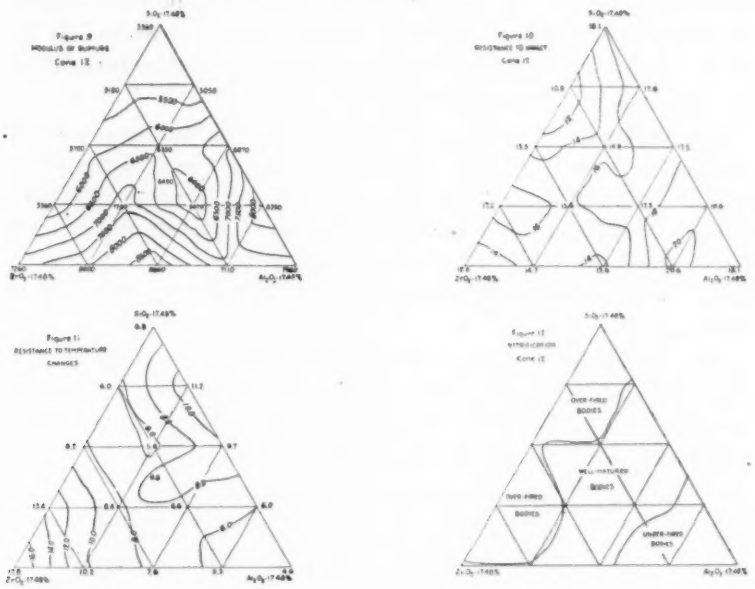
Shrinkage.—Linear drying and total shrinkages were measured on the rectangular bars which had shrinkage marks $2^1/_2$" long on both sides. They were calculated in terms of wet length. The firing shrinkage was represented by the difference between the total and drying shrinkages.

Transverse Strength.—The rectangular bars were broken in a Riehle transverse strength testing machine.

The following formula was used for calculations:

$$\text{Modulus of rupture} = 3/2\frac{PL}{bd^2}$$

P = breaking load in pounds.
L = span of the knife edges = $3^1/_2$".
d = depth of the bar tested in inches.
b = breadth of the bar tested in inches.



Absorption.—Three broken bars of each body were selected for the absorption test. They were weighed dry, then immersed in water which was boiled during the 1st, 25th, 50th, 75th, and 100th hours of immersion. They were then weighed again wet.

$$\% \text{ absorption} = \frac{\text{Wet wt.} - \text{dry wt.} \times 100}{\text{Dry wt.}}$$

Heat Resistance Test.—(a) *On Test Pieces Fired to Cone $8^1/_2$–9.* Four discs from each body were subjected to a test for resistance to sudden temperature changes. An oil-fired enameling furnace was used. The discs were subjected to a red heat (about 1600°F) for seven minutes; then immediately dropped into a tub of cold

water. The data given in the table represent the number of heats stood by the test pieces without breaking.

(b) *On Test Pieces Fired to Cone 12.*—Since the heat resistance test used on the discs fired to cone $8^1/_2$–9 proved to be too severe, a milder test was used on the discs fired to cone 12. The electric enameling furnace was used. Five discs of each body were placed in the preheating chamber at 450°F for 5 minutes and then transferred to the hot chamber at 1560°F for 7 minutes. While the discs were red hot they were dumped into cold water (60°F). When cooled they were immediately returned to the preheating chamber and the process repeated.

Impact Test.—The impact test consisted in dropping an 852 gram weight upon a disc. The weight was allowed to drop first from a height of $2^1/_2''$ above the top of the disc; then at increasing heights of $^1/_2''$ until the disc was broken. The top and bottom of the disc were covered with cardboard to prevent unequal pressure. The results were recorded in inches of drop required to break.

Dye Penetration Test.—The broken pieces from the impact test were subjected to a dye penetration test under a constant pressure of 250 lbs. per sq. in. for 16 hours. The varying degrees of porosity were designated as follows:

N. P. — Non-Porous — No penetration.
P — Porous — 1/16″ or less penetration.
V. P. — Very Porous — Over 1/16″ penetration.

SUMMARY OF DATA (CONE $8^1/_2$–9)

Body No.	Shrinkage, % of Wet Length			Absorption, % of Dry Weight			Dye Test
	Drying	Burning	Total	Min.	Max.	Av.	
1	6.0	11.0	17.0	0.017	0.034	0.023	N.P.
2	6.0	.5	.5	.053	.155*	.054	N.P.
3	5.5	12.0	.5	.034	.063	.045	N.P.
4	.3	.2	.5	.049	.068	.055	N.P.
5	.3	11.6	16.9	.114	.118	.116	N.P.
6	4.9	10.9	15.8	.15	.196	.174	N.P.
7	5.5	11.6	17.1	.146	.212	.173	N.P.
8	.8	12.8	18.6	.078	.088	.083	N.P.
9	.2	11.7	16.9	.121	.127	.124	N.P.
10	6.0	.9	17.9	.042	.878	.358	P.

11	4.8	10.4	15.2	0.271	0.93	0.650	P.
12	5.5	12.2	17.7	.044	.087	.068	N.P.
13	.2	.1	.3	.13	.69	.328	N.P.
14	4.5	11.7	16.2	.792	1.26	.941	N.P.
15	5.1	10.8	15.9	3.37	3.90	3.56	V.P.
16	.3	10.0	.3	2.79	7.40	5.10	V.P.

	Modulus of Rupture. Lbs. per sq. in.			Resistance to Temperature Changes. Number of Heats Withstood			Impact Test. Inches of Drop		
Body No.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
1	2780*	7700	6400	3	6	4.5	12.5*	22.0	21.3
2	4330	7560	6400	1	6	2.75	17.0	34.5	23.6
3	3790	9210	6900	4	6	5.0	15.0	37.0	.1
4	5200	8340	7300	1	6	2.25	17.5	28.5	25.0
5	5280	8150	6800	1	6	3.25	15.5*	30.0	28.1
6	4120	7650	5400	1	5	2.75	.0*	25.0	24.5
7	5130	7550	6300	1	3	.5	.5*	21.5	20.8
8	3270*	7950	6500	3	6	4.0	18.0	24.5	22.0
9	4470	8250	7000	1	5	2.75	17.0	22.0	20.0
10	5520	7760	6500	1	2	1.25	19.0	26.0	22.5
11	4610	7040	5200	2	3	2.50	21.5	29.5	25.4
12	4670	8400	6100	1	1	1.0	15.0	21.5	18.1
13	4750	6700	5550	1	3	.5	17.0	30.5	23.6
14	3770	5370	4700	1	6	3.25	20.0	27.0	.2
15	5030	6850	5700	1	3	1.5	15.0*	20.0	19.0
16	4050	7750	5400	1	7	3.5	13.0	24.0	17.6

* Extremely irregular figures discarded.

Comment on Results (Cone $8^1/_2$-9)

Total Shrinkage.—Figure 2 shows that the substitution of ZrO_2 for free SiO_2 slightly increases the shrinkage. The substitution of Al_2O_3 for the free SiO_2 decreases the shrinkage, due to the decreased vitrification. There are points of maximum shrinkage when 75% of the free SiO_2 is replaced by ZrO_2 or by 25% of ZrO_2 and 50% of Al_2O_3.

Absorption.—*Cone* $8^1/_2$–9. Figure 3 shows that the substitution of ZrO_2 for free SiO_2 gives a slight increase in absorption with a maximum absorption at 75%, ZrO_2 to 25% free SiO_2. An increase of Al_2O_3, at the expense of the free SiO_2 or ZrO_2 shows a great increase in absorption.

Modulus of Rupture.—Figure 5 shows a point of maximum rength at 50% of free SiO_2 replaced with ZrO_2. The substitu-

tion of Al_2O_3 for either free silica or ZrO_2 shows a decreased strength due to decreased vitrification.

Impact Strength.—Figure 6 shows the replacement of free SiO_2 by either ZrO_2 or Al_2O_3 up to approximately 50% gives bodies of increased resistance to impact. Maximum resistance to impact is reached with 50% of free SiO_2 replaced by 25% each of ZrO_2 and Al_2O_3.

Heat Resistance.—The heat resistance test was too severe and really shows little.

SUMMARY OF DATA (CONE 12)

	Shrinkage, % of Wet Length			Absorption		
Body No.	Drying	Burning	Total	Min.	Max.	Av.
1	6.0	9.3	15.3	0.053	3.10	1.45
2	4.4	10.1	14.5	.224	1.67	0.72
3	5.5	.9	16.4	.094	0.063	.058
4	.2	11.6	.8	.147	.165	.158
5	5.0	.3	.3	.070	.125	.104
6	5.0	.4	.4	.082	.129	.113
7	.5	.7	17.2	.087	.093	.089
8	.2	.4	16.6	.222	2.12	1.08
9	6.2	13.3	19.5	.101	0.148	0.114
10	5.0	12.1	17.1	.094	.140	.111
11	5.0	12.4	.4	.158	.208	.179
12	.4	14.1	19.5	.112	.123	.119
13	5.0	13.8	18.8	.130	.163	.141
14	4.5	10.7	15.2	.126	.134	.129
15	.5	11.5	16.0	.234	.268	.246
16	5.0	.5	.5	.254	.370	.303

(CONE 12)

	Modulus of Rupture in Lbs. per square inch			Resistance to Temp. changes in No. of Heats Withstood.			Impact Test in Inches of Drops		
Body No.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
1	4150	6160	5560	5.0	10.0	6.8	15.0	18.0	16.1
2	3600	6250	5180	1.0	10.0	6.0	8.5	17.0	10.9
3	3190	6200	5050	5.0	23.0	11.2	.5	23.5	17.6
4	3740	8050	5700	4.0	14.0	8.2	11.0	16.0	13.5
5	5660	7030	6350	1.0	10.0	5.6	12.5	15.0	14.8
6	6230	8080	6970	6.0	17.0	9.7	16.0	19.0	17.5
7	5850	7500	6450	5.0	17.0	.8	14.0	22.0	18.2
8	4300	6900	5560	8.0	25.0	13.4	13.5	20.5	17.2
9	5850	8700	7280	5.0	10.0	8.2	13.0	18.5	15.6
10	3420	8110	5620	5.0	9.0	6.6	.5	22.5	17.3

11	7410	9350	8390	5.0	8.0	6.0	15.5	21.5	19.6
12	6720	7550	7260	7.0	25.0	17.8	7.1	17.0	12.0
13	7150	8950	8000	6.0	21.0	10.2	14.5	18.5	14.7
14	7870	9290	8860	5.0	10.0	7.6	10.0	16.5	13.6
15	6510	8000	7110	4.0	8.0	5.3	18.5	22.5	20.6
16	5200	9860	7360	3.0	8.0	4.6	15.0	22.0	18.1

Comment on Data

Total Shrinkage.—On the whole the total shrinkage increases with the increase of ZrO_2 at the expense of the flint. The same is true when Al_2O_3 replaces the flint. Bodies 9 and 12 have maximum shrinkage.

Absorption, Cone 12.—Minimum absorption is found in the bodies located in the middle of the triaxial diagram between the high and the low alumina. The 0.15% absorption contour lines form the boundry of the field of well matured bodies. Thus in general it may be said that 4 to 9% additions of Al_2O_3 as a refractory oxide in a porcelain body are desirable for the production of bodies with a long heat range.

Resistance to Temperature Changes.—ZrO_2 stands out as an ingredient which produces bodies capable of resisting temperature changes. The more ZrO_2 used in place of the flint, the greater is the resistance to temperature changes. Al_2O_3 seems to produce the opposite effect although the replacement of 25% of the flint with Al_2O_3 produces a good body with reference to its ability to stand temperature shocks.

Modulus of Rupture.—Bodies 1, 2, 4, and 8, are much lower in transverse strength at cone 12 than at cone $8^1/_2$ due to overburning. The bodies relatively high in Al_2O_3 show a much increased strength at cone 12 because of their increased vitrification. Bodies 11, 13, and 14 have the highest strength at this temperature. The results obtained are difficult to interpret. The increased transverse strength of these bodies at the higher temperature may be due to the formation of sillimanite.

Resistance to Impact.—On the whole the high alumina bodies are most resistant to impact. The bodies with high flint and high ZrO_2 show low impact values due to overburning.

COMPARISON OF DATA OBTAINED

Body No.	Absorption. % of Dry Wt. Cone 8½-9	Absorption. % of Dry Wt. Cone 10½	Absorption. % of Dry Wt. Cone 12	Modulus of Rupture. Lbs. per sq. in. Cone 8½-9	Modulus of Rupture. Lbs. per sq. in. Cone 12	Resistance to Temp. Changes. No. of Heats. Cone 8½-9 *	Resistance to Temp. Changes. No. of Heats. Cone 12 *	Resistance to Impact. No. of Inches. Cone 8½-9	Resistance to Impact. No. of Inches. Cone 12
1	0.023	0.072	0.161	6400	5560	4.5	6.8	21.3	16.1
2	.054	.106	.142	6460	5180	2.7	6.0	23.6	10.9
3	.045	.106	.058	6900	5050	5.0	11.2	.1	17.6
4	.055	.117	.151	7300	5700	2.3	8.2	25.0	13.5
5	.116	.121	.104	6800	6350	3.3	5.6	28.1	14.8
6	.174	.119	.113	5400	6970	2.8	9.7	24.5	17.5
7	.173	.074	.089	6300	6450	.5	.8	20.8	18.2
8	.083	.061	1.08	6500	5560	4.0	13.4	22.0	17.2
9	.124	.093	.114	7000	7280	2.8	8.2	20.0	15.6
10	.358	.136	.111	6500	5620	1.3	6.6	22.5	17.3
11	.659	.169	.179	5200	8390	2.5	6.0	25.4	19.6
12	.068	.110	.119	6100	7260	1.0	17.8	18.1	12.0
13	.328	.134	.141	5550	8000	.5	10.2	23.6	14.7
14	.941	.163	.129	4700	8860	3.3	7.6	.2	13.6
15	3.56	.151	.246	5700	7110	1.5	5.3	14.0	20.6
16	5.10	.189	.303	5400	7360	4.5	4.6	17.6	18.1

* Comparison should not be made between these columns as different methods of testing were employed.

High alumina bodies Nos. 10, 11, 13, 14, 15 and 16 require a temperature higher than cone 9. Bodies 1, 2, 4, 8, and 12 become overfired at cone 12. Eliminating these, there remain bodies Nos. 3, 5, 6, 7, and 9, which have an unusually long vitrification range. Among these bodies No. 9 is considered to be the best. No. 3 is valuable for its long vitrification range and high resistance to heat shocks. Body No. 12 is valuable for its resistance to heat shocks. It should not be burned above cone 11.

Dielectric Test.—Since body No. 9 was considered the best one of the series, new batches of it were prepared and of body No. 1 in order to compare their dielectric strengths. The two bodies were blunged, lawned through a 60 mesh lawn and filter-pressed. Tubes of $^3/_4$″ outside diameter and $^7/_{16}$″ inside diameter were made by pressing each body through a die. These were cut into 8″ lengths. The high potential test was made at 60 cycles, using a 100,000 volt transformer. The current was applied near the center of the specimen through a band of tin foil $^1/_2$″ wide. The

interior electrode consisted of a column of mercury. During the test the specimen was immersed in oil. An initial voltage of 10,000 volts was applied and this was increased every ten seconds by increments of 5,000 volts until 25,000 volts was reached. Jumps of 2,500 were then used until 30,000 volts was reached. From 30,000 volts upwards the voltage was increased 1,000 volts every ten seconds until breakdown occurred. The results were consistent.

The averages of ten trials were as follows:

Body No. 1—150 volts per mil.
Body No. 9—145 volts per mil.

Conclusions

The Effects of the Use of Zirconia to Replace Flint.—(a) Overburning of the porcelain occurs at a lower temperature. (b) The ability to withstand sudden temperature changes is greatly increased. (c) The firing shrinkage is increased. (d) The transverse strength is highest with equal parts of zirconia and flint. (e) The color is poorer.

The Effects of the Use of Calcined Alumnia to Replace Flint. (a) The maturing temperature of the porcelain is greatly raised. A small amount of calcined alumina greatly decreases the danger of overburning. (b) The ability to withstand sudden temperature changes is greatly decreased. (c) The firing shrinkage is decreased. (d) When a body containing calcined alumina approaches vitrification, it has high transverse strength.

Dielectric Strength. The result of the dielectric test is disappointing since it is the reverse of what was expected. Under the conditions of the test the presence of free silica has a desirable effect on the dielectric strength.

Heat Resistance. The results indicate that zirconia is of great value in bodies which must stand sudden temperature changes. Of the three materials tested, flint is next in value to zirconia in this respect while calcined alumina is very poor.

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TESTS OF FIRE-BRICK MADE FROM GANISTER, FLINT CLAY, AND PLASTIC CLAY MIXTURES, WITH SPECIAL REFERENCE TO SPALLING[1]

By Raymond M. Howe[2] and Mark Sheppard[2]

ABSTRACT

Influence of the alumina-silica ratio on properties of fire-brick.—Five experimental batches of fire-brick were made by mixing various proportions of ganister, flint clay and plastic clay in such a way as to vary the silica content from 53 to 77 per cent and the alumina content from 43 to 20 per cent. (1) **The fusion points** were found only slightly lower than those of corresponding pure silica-alumina mixtures. (2) **Load tests at high temperature** showed that the behavior under compression does not depend on chemical composition so much as on other factors such as the temperature of burning. (3) **The resistance to spalling,** as tested by alternate heating and dipping in cold water, was found to decrease as the temperature of burning was increased from 1300° to 1400°C. The higher silica bricks were relatively more resistant at the lower temperature but not so at 1400°C. Therefore the substitution of ganister for flint clay increases the resistance to spalling at moderate operating temperatures but is of no advantage at 1400° or above.

The influence of the alumina-silica ratio of fire-brick has been the subject of considerable discussion and has often led to a conflict of opinions. For example, bricks high in alumina often give unusually good service because of their high fusion points. Under other conditions these same brick give less satisfactory service than those which are high in silica. Therefore, five experimental batches of fire-brick were made under plant conditions from the raw materials described in table I in order to study the effect of varying the silica content. This variation was secured by replacing flint clay with ganister.

[1] Received January 31, 1920.

[2] Fellows, Refractories Manufacturers Association, Mellon Institute of Industrial Research, Pittsburgh, Pa.

TABLE 1.—COMPOSITION OF MATERIALS USED.

	Flint clay	Plastic clay	Ganister
Silica	50.53	63.55	98.24
Alumina	46.35	29.19	0.98
Ferric oxide	2.30	2.39	.24
Lime	trace	0.52	trace
Magnesia	trace	1.36	0.12
Soda	0.81	1.00	.20
Potash	.51	.78	.18
TOTAL	100.32	99.79	100.20
Fusion point	Cone 34–35	Cone 26	Cone 33

The bricks were "hand-made" from the mixtures given below and had the indicated chemical composition and fusion point.

TABLE II.—COMPOSITION OF FIRE-BRICKS USED IN INVESTIGATION

Number	1	2	3	4	5
Parts ganister	0	10	30	40	50
Parts flint clay	80	70	50	40	30
Parts plastic clay	20	20	20	20	20
Fusion point	Cone 33	Cone 32–33	Cone 30–31	Cone 29–30	Cone 27
Silica per cent	52.95	57.87	67.26	72.14	77.04
Alumina per cent	42.95	38.34	29.35	24.81	20.28
Ferric oxide per cent	2.32	2.10	1.70	1.50	1.29
Lime per cent	0.10	0.10	0.10	0.10	0.10
Magnesia per cent	.31	.31	.31	.32	.33
Soda per cent	.67	.67	.67	.60	.54
Potash per cent	.67	.66	.66	.63	.60
TOTAL PER CENT	100.20	100.05	100.05	100.10	100.14

Specimens of each mixture were also subjected to the load, reheating and spalling tests. In some cases the tests were applied on the bricks as received; in other cases the reheating and load tests were used in conjunction and in several instances the spalling tests were preceded by reheating tests.

The load tests involved the standard temperature of 1350°C and a pressure of 25 pounds per square inch; the reheating tests were conducted over a period of 5 hours at the indicated temperatures. The spalling tests consisted of heating the specimens in the door of a furnace (operating at 1350°C) for one hour, partially immersing in a trough of running cold water, air-drying, and repeating the operation. The results of the various tests, with the necessary explanations, are given in table III.

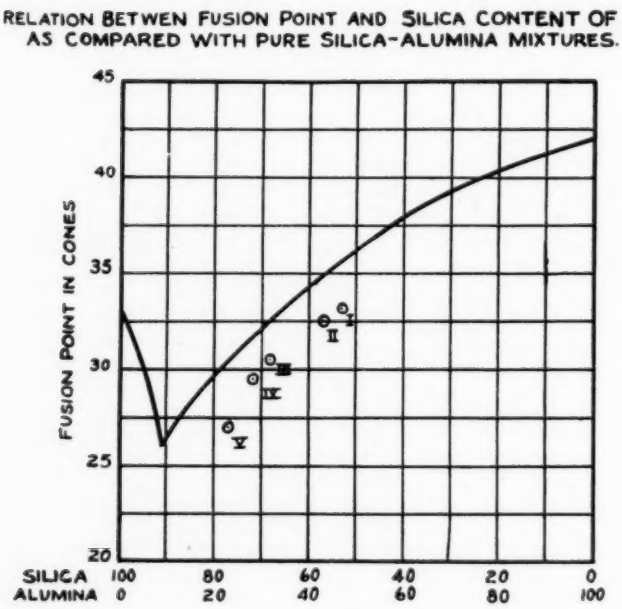

FIG. 1.

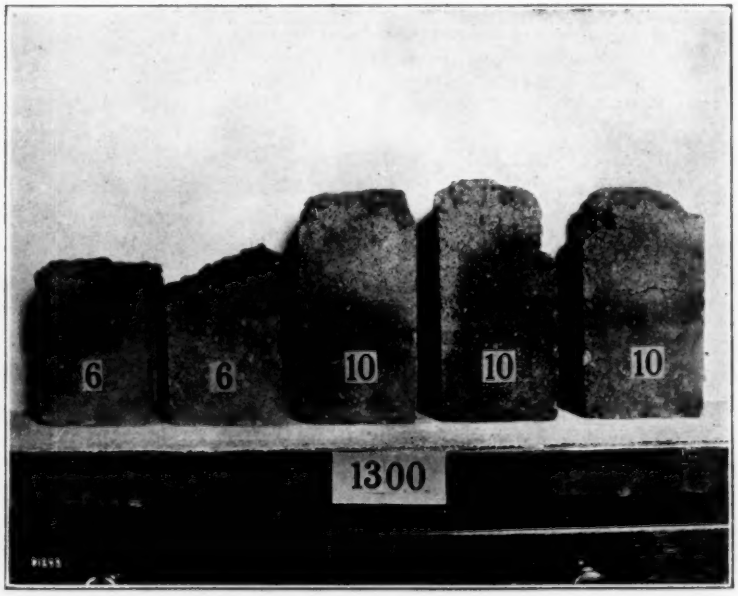

FIG. 2.—Condition of specimens 1 to 5 (left to right) after reburning at 1300°C and indicated number of dips.

TABLE III.—RESULTS OF PHYSICAL TESTS ON FIRE-BRICK

Number of brick	1	2	3	4	5
Silica content of brick					

TABLE 111.—RESULTS OF PHYSICAL TESTS ON FIRE-BRICK

Number of brick	1	2	3	4	5
Silica content of brick	52.95	57.87	67.26	72.14	77.04
Fusion point of brick	Cone 33	Cone 32½	Cone 30−½	Cone 29½	Cone 27
Permanent linear change after heating five hrs. at 1300°C	0.00	0.16% contraction	0.22% contraction	0.16% contraction	0.16% contraction
Permanent linear change after heating five hrs. at 1400°C	.61% expansion	0.24% contraction	0.22% contraction	0.63% contraction	0.60% contraction
Per cent compression in 1350°C load test. Bricks tested as received	5.2	4.3	11.3	7.9	8.5
Per cent compression in 1350°C load test. Bricks first reburned 5 hrs. at 1300°C	4.2	5.4	8.3	10.8	10.0
Per cent compression in 1350°C load test. Bricks first reburned 5 hrs. at 1400°C	1.6	2.2	6.2	7.5	7.6
Per cent lost after 26 dips in spalling test. Bricks tested as received	1.0	2.0	3.0	4.0	4.0
Per cent lost after 6 dips in spalling test. Bricks heated 5 hrs. at 1300°C before testing for spalling	30.7	33.3	0.0	0.0	0.0
Per cent lost by same bricks after 10 dips	stopped at 6	stopped at 6	4.9	8.5	15.3
Per cent lost after 5 dips in spalling test. Bricks heated 5 hrs. at 1350°C before testing for spalling	50.0	50.0	0.0	0.0	0.0
Per cent lost by same bricks after 8 dips	stopped	stopped	20.0	8.0	15.0
Per cent lost after 4 dips in spalling test. Bricks heated 5 hrs. at 1400°C before testing for spalling	0.0	50.0	0.0	0.0	0.0
Per cent lost by same bricks after 5 dips	44.5	stopped at 4	0.0	36.3	39.8

DISCUSSION OF RESULTS

1. Fusion Points

The fusion points of the bricks decreased gradually as the silica content increased, and were usually about two cones lower than the fusion points of the corresponding alumina-silica mixtures. (See Fig. 1.) The tests were made both upon ground and chipped cones. The results are in accordance with the opinion that fusion points of fire-brick are controlled to a large

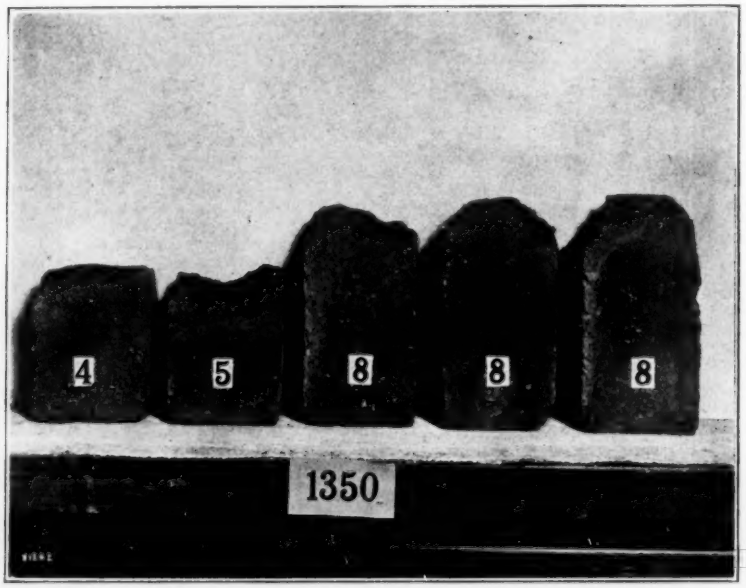

FIG. 3.—Condition of specimens 1 to 5 (left to right) after reburning at 1350°C and dipping the number of times indicated.

extent by their alumina and silica contents as well as by their impurities. A high alumina content is therefore desirable when the bricks are subjected to extremely high temperatures. This condition is found in electric, malleable iron, and grey-iron furnaces.

2. Behavior Under Load

When the chemical analyses of the five bricks are examined, it is evident that numbers 4 and 5 have the same compositions

as those brick which undergo little or no compression in the load test. Numbers 4 and 5, however, showed higher compressions than numbers 1 and 2, which are lower in silica. Consequently it was demonstrated that behavior under load at high temperatures is not a function of chemical composition, but of other factors.

One of these factors is the "burn" of the fire-brick, for the compression was decreased considerably by reburning at a higher

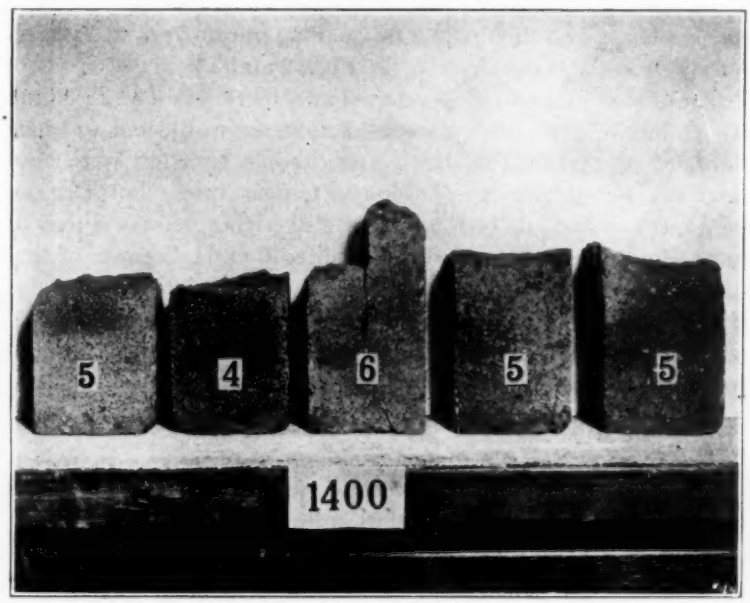

FIG. 4.—Condition of specimens 1 to 5 (left to right) after reburning at 1400°C and dipping the indicated number of times.

temperature. Apparently the tendency to contract under atmospheric pressure is developed more completely under the higher pressure of the load test.

3. Spalling

There was little to be learned from the spalling tests made upon the bricks which were tested as received. The fact that they were well bonded and free from lamination was demonstrated, but no other conclusions could be drawn.

When specimens were heated for five hours at 1300°C, prior to testing for spalling, more satisfactory results were obtained. Bricks numbers 1 and 2 became partially vitrified during reburning and failed after 6 dips in the spalling test. Numbers 3, 4, and 5 did not become partially vitrified in reburning and lost very little after 10 dips. (See Fig. 2.)

There was also a distinction between the bricks which were reburned for five hours at 1350°C, although the difference was less pronounced. When the bricks were first heated to 1400°C for five hours and then tested for spalling, numbers 1, 2, 3, 4, and 5 showed similar behaviors. (See Figs. 2 and 3.)

These tests, therefore, developed two facts: (1) The resistance to spalling of each brick decreased as it was subjected to higher temperatures. (2) The bricks containing ganister were most resistant to spalling at the lower temperatures, but this advantage was lost at 1400°C.[1] At still higher temperatures the more aluminous bricks would undoubtedly excel because of their higher fusion points.

Consequently the use of ganister should be highly desirable to prevent spalling in beehive coke oven shapes, but would not be justified in the manufacture of "bung" brick.

Conclusions

The opinion that the fusion point of a fire-brick is a function of chemical composition was verified, for the fusion points of the five bricks showed a close relationship to those of pure silica-alumina mixtures. This is not true for the behavior of a fire-brick under load at high temperatures, for those which should have shown the least compressions (judging by their chemical analysis) showed the most. The character of a fire-brick in this respect depends more upon the nature of the raw materials used and upon its physical characteristics. The substitution of ganister for flint clay increases the resistance of a fire-brick to spalling at moderate operating temperatures, but is of no advantage at the highest temperatures at which fire-brick are used.

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[1] In view of the load test results, conclusions drawn from brick of this type should not be applied to the silicious brick from New Jersey

SOME APPLICATIONS OF THE DRUM AND CABLE IN A BRICK PLANT

By Robert Twells, Jr.

ABSTRACT

Application of the drum and cable in a brick plant, for plowing and scraping the shale, for transferring it to the driers and out again and for carrying the burned bricks to the freight cars are described. The devices are simple and cheap, but they have effected a great saving and have made it much easier to get the necessary labor.

Introduction

In his address as retiring president R. T. Stull has called attention to the relative importance of the brick industry and its great need for what he terms "mechanical assistance." It is the purpose of the following article to describe certain labor-saving devices, in use in a face and paving brick plant, of such unique character that the writer believes their description may serve as a contribution to the knowledge of proper mechanical construction and arrangement of brick plants. The drum and cable system, used in many brick plants to draw the cars from pit to clay bin, with modifications, is the basis of most of these devices.

Method of Winning the Shale

The shale bank had originally presented considerable difficulty. The plant itself is in a valley closely surrounded on three sides by high steep ridges. It is necessary to lower the shale to the plant, sometimes using two levels and dumping the shale from one car to the next. The shale is fairly soft. Its strata are almost vertical, with streaks of rock at varying intervals. A steam shovel was practically out of the question due to the nature of the ground, and to the difficulty of avoiding the rock. As a result, hand shoveling was used.

The problem was solved in this way: A small frame building was built and mounted on low wheels so that it could be moved on a standard gauge track, the frame work of the building being

made strong enough to stand severe shock. Three drums are mounted in this car and connected to a 25 H. P. motor. The cable from one of these drums is fastened to the front end of either a plow or a scraper, and is used to pull them forward. The cable from the second drum is fastened to the back of either the plow or the scraper and is used to pull them back from another trip. The cable from the third drum is used to lower the clay car to the factory to be emptied and to draw it up again to be loaded.

The method of gathering the shale is simple. A heavy narrow plow without handles is drawn back and forth tearing up the shale. When enough has been torn loose to provide several hours work the cables are taken from the plow and fastened to an ordinary large drag scraper. The shale is scooped up and carried to a trestle where it is automatically dumped into a clay car. This system is very flexible. The digging machine may be placed upon the top of a bluff or in a hollow. The plow and scraper can work up or down a steep slope. The usual method of working is to build the clay car track close to a steep bank; a trestle is built over the track and the shale is dropped down the hill and dumped through the trestle into the clay car. In time the hill is worked away, and replaced by a shallow pit, probably 100 feet in diameter. The pit is always worked in such a way as to insure natural drainage. By slightly altering the position of the digging machine or by moving the trestle another supply of shale may be opened up for use.

The advantages of this method over hand digging are: (*a*) it saves the labor of 4 or 5 men; (*b*) it makes the work easier for the men; (*c*) it insures dry shale even in winter; (*d*) the location seldom needs changing; it stays in one place from 3 to 6 months; (*e*) it has great capacity; it "puts down" shale for 50,000 brick in 4 to 5 hours; (*f*) practically no repairs have been needed in three years; (*g*) no powder or dynamite are required; (*h*) it avoids ledges of rock which the explosives used in connection with hand digging, would scatter into the shale.

Moving the Stored Shale to the Dry Pans

The shale for use in bad weather is dumped from a trestle into a long shed adjoining the dry pans. A long conveyor belt was

tried, but it gave so much trouble that it was finally torn out and the shale was wheeled to the dry pans in barrows. This was not only expensive but labor for such work was almost unobtainable. The scraper system had been so satisfactory on the shale bank that a motor and two drums were installed in the storage shed. The shale is now being moved from anywhere in the shed to the dry pans. The same gang which ordinarily works the regular digger on the shale bank merely changes over to the other machine in bad weather instead of laying off to avoid wheeling shale.

The remainder of the labor-saving devices center about the hot end of the drier. The motor that turns the drier fan is also made to turn four drums which serve various purposes, as explained below.

Pulling the Cars from the Drier

Before the installation of this method it had been customary to stop the brick machine gang twice during the morning and afternoon to let down the cars in the drier. Half the men went to the cool end of the drier to push the cars; the other half went to the hot end to hold them from running too fast. A half hour of time was lost at each stop, and much confusion and many wrecked cars resulted.

This was remedied by placing a drum in the fan house and running the cable out to the front of the drier. By changing its direction with sheave wheels the cable could be made to pull in line with any tunnel. It was not considered practical to couple the cars together so the following method was used. A separate cable is placed in each tunnel. When the operator wishes to pull a string of cars, he enters the cool end of the drier and fastens the last car to the cable. To do this he uses a short piece of chain with a hook on one end and a clamp on the other. The clamp is similar to that used on a wire stretcher. It can be clamped to the cable at any place in the drier since the length of the string of cars is variable. After fastening the last car to the cable the operator returns to the hot end of the drier, fastens the pulling cable to the short length of cable in the tunnel, places his back against the first car to keep them from moving faster than the cable, applies the power, and walks out ahead of the cars. He applies the power by pulling on a rope which in

turn moves the belt on a tight-and-loose pulley on the drum. By this method one man can easily pull 100 cars from the drier in six hours. He draws them as they are needed, so there are always cool cars for the setters. There is practically no wreckage of the cars.

Power Transfer Car

The transfer car at the hot end of the drier gave some trouble. It became difficult to get men to pull it as the job was looked upon as a "man-killer." The setters on the more distant kilns lost time since they had to wait for the man to get back with a new car. An electrically driven car would have been satisfactory, but its cost and upkeep would have been high. It was therefore decided to use the drum and cable system. A stout frame was built near the transfer track and a driving shaft run to the frame from the dryer-fan motor. Two drums were mounted on the frame and geared to run in opposite directions. They were controlled by friction clutches. The cables from these drums were fastened one on each end of the transfer car. The operator merely stands at the frame and works his levers. He can "spot" the car quite accurately. The use of power for the transfer car did not save the labor of a man, but it made his work so much lighter, and so speeded up a lagging end of the plant that the change has been well worth while.

The drier car had to be pushed up an incline in order to give the necessary slant to enable it to run back to the machine room. This had always been a hard job for one man. It was therefore also eliminated by means of a small drum and clutch placed on the shaft between the fan house and the drums.

A Coal Handling Device

The coal for the kilns is dumped from the coal cars onto a trestle about a hundred feet from the fan house, at the hot end of the drier. A horse and cart is used to deliver coal to the kilns. The cart had first to be backed down under the trestle and filled by shovel. A track was therefore laid from the trestle to a platform high enough to enable a car of coal to be dumped directly into the cart. A cable from the fan house drum pulls the car up this incline. The power is applied in this case by pulling on a

rope which moves the belt to the drum of a tight-and-loose pulley. The car is very low and is easily filled. It holds just enough to fill the cart. Now one man loads the car while the other dumps the cart. The work is much easier on both, the kilns are soon coaled, and the men may be used to cart away bats and ashes.

New Labor Saving Service Planned

The drum and scraper method of handling shale has proved to be so satisfactory that the company is planning to tear out its high elevators, lower the pug mill and screens, and put in a scraper to draw the ground shale from the foot of the dry pans to the screens. They believe that by eliminating their elevators they can cut out at least half of their losses due to breakdown and repairs.

The plant has at present under construction a rather novel method of trying to solve the brick wheeling problem. This is more difficult on account of the flexibility which such a system must have. A temporary track built in easily movable sections is to be used. This will be laid between the kiln and the freight car or stock pile. Three temporary tracks will be laid into the kiln. The workman will place brick on low trucks, which will hold only 100 bricks so that they may be easily handled. There is a slight drop between the kiln and the freight cars which makes a gravity system possible. A drum will be placed at the kiln door; a cable, fastened to the loaded truck, will pass around the drum and will be fastened to an empty truck. In this way the full truck will pull the empty truck back to the kiln. The advantages of this plan are: (1) skilled men are no longer required; (2) it enables the men to work during bad weather since both ends are under cover; and (3) it speeds up production by emptying the kiln more quickly. This method has been tried out and found to be very successful.

The different devices described are essentially simple and their cost has been negligible, since, in most cases, they were built in the spare time of the regular blacksmith and carpenter, using, to a large extent, waste material. They have, however, effected a great saving and have enabled the company to compete success-

fully for labor against the lighter factory work. They are not new in principle nor could they be successfully applied to all plants but their description serves to show the possibilities of the drum and cable as a labor-saving device.

A SIMPLE EXPANSIBILITY TEST FOR DETERMINING THE WELDING PROPERTIES OF GLASSES[1]

By Donald E. Sharp

ABSTRACT

Simple method of determining the relative expansibilities of two glasses.—Place two rods of glass side by side with the ends flush, heat these ends, weld together by pinching with forceps and then pull out a thread or thin strip with the two glasses forming opposite sides. When cool the thread will bend toward the glass having the higher total expansion up to the softening point of the softer glass. This test may be used for quantitative **determination of coefficients of expansion** if a series of glasses of known expansibilities are available for comparison. The method is of particular value for investigating the **welding properties of glasses,** for whether or not two glasses can safely be welded together may be determined directly from the amount of curvature of the thread.

In the factory manipulation of colored and clear glasses, it is frequently found necessary to weld together two glasses, or to coat a thin layer of colored glass with a thicker layer of clear glass. The former is usually called welding or casing, and is employed in the manufacture of ornamental and fancy wares. The latter is called flashing, and applies particularly to the manufacture of colors such as copper ruby where the depth of color is so great that the glass must be blown very thin in order to transmit an appreciable amount of light. It is consequently necessary in the latter case to coat the thin layer of colored glass with a much heavier layer of clear glass to give the ware the requisite mechanical strength and "body" to bear working in the blowing room and in its later use. The manufacturer of glass laboratory apparatus also, must often join tubing from two different sources, or seal some tubing to a piece of apparatus from another maker. It, therefore, becomes a matter of importance to learn whether or not the two glasses will seal without subsequent fracture.

It has been found that some glasses of widely different com-

[1] Received, July 17, 1920.

position and physical properties can be welded together under certain circumstances and in certain shapes. The compound glass which has found some use for boiler gauge tubes is an excellent example of this kind of welding. These tubes are made by covering a layer of glass of one expansibility with a layer of glass of smaller expansibility. It is the difference in the expansion coefficients which in this case makes the compound gauge tube so tough.

In general, however, two glasses can not be welded or sealed together unless their coefficients of expansion are very nearly identical. In the compound tubes mentioned above it is possible to effect a seal, only because the strain is symmetrical and of such character that the forces brought into play in the weakest part of the tube are forces of compression rather than of tension.

Appert[1] suggests that the conditions necessary for successful welding are: (*a*) The glasses must have the same coefficients of thermal expansion over the range of temperature to which the finished articles are likely to be submitted; (*b*) the diathermancies, or power of transmitting heat, must be equal; (*c*) the glasses must be inert and sustain no change whatever during the heating necessary in welding. He states also that the first condition is the most important and applies to all cases while the other two are only of secondary importance. A method of determining the state of tension existing between two glasses, which is described in detail in his article, might, indeed, find good application in the blowing room of a glass factory.

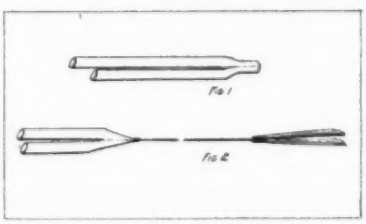
This method consists of blowing three bulbs from combinations of the two glasses under test. Calling the glasses A and B; one of the bulbs is blown of A glass alone and is reserved as the standard. The other two bulbs are made of both A and B glasses—number 1 of a layer of A coated with a layer of B, and number 2 of a layer of B coated with A. The determination of the welding properties of the two glasses is then made by finding the resistance of numbers 1 and 2 to shock, as compared with the standard bulb of A glass. If the glasses differ in expansibility one of the bulbs is likely to burst violently while the other will be very resistant to shock due to the similarity to toughened or oil-

[1] Appert, *Bull. Soc. d'encour. l'ind. nat.*, Jan., Feb., 1919.

hardened glass. When the bulbs number 1 and 2 do not seem to differ from the standard in their susceptibility to breakage or to cutting with the diamond, the bulbs are perfectly sealed and no state of tension exists.

While this test is undoubtedly satisfactory for use in the blowing room of a glass factory where the glass may be had in quantity, and may be manipulated on the blowing iron, it is not suitable for laboratory use, nor is it convenient for the lampworker's use before the blast flame. A method that has been used by the author for several years, and found very satisfactory, permits a test in the laboratory by means of a blast lamp, and is both quick and reliable. It has also the advantage of requiring only very small pieces of the glass under test.

The two glasses, whose properties of sealing together are to be tested, are worked out before the blast lamp or over a Meker burner into small rods. The ends of these rods are then heated



to softness and the two rods held together, and along side of one another, so that the ends which were softened weld together and form a single rod (Fig. 1). The junction is now carefully heated to softness and shaped slightly with a pair of forceps, into a form which may easily be pulled out. The end of the junction is now seized with the forceps in order to support it, and the flame allowed to strike on the thinner area of the compound strip that has been formed, in such a manner as to heat both glasses equally. As soon as the junction is soft enough, the rods are removed from the flame, still being held with the forceps, and the junction pulled out quickly into a thin strip or thread about 10–15 inches long, the tension being maintained until the softened glass has cooled below its deformation temperature (Fig. 2). The heavy end formerly held in the forceps

is now broken off and the thread held in a vertical position for examination.

The thin thread formed by drawing out the junction of the two pieces of cane is in reality a strip similar to the familiar metal thermostat. If the glasses composing the strip have different coefficients of expansion, a greater contraction occurs on one side of the strip than on the other and the strip bends into a curve, the glass of higher coefficient of expansion being on the inside of the curve. Glasses differing greatly in expansibility will give strips that will actually wind up into spirals when the tension is released, while those differing but little will show only a very slight departure from straightness. No curvature at all would, of course, be an indication that the glasses had identical expansion coefficients.

In employing this test as a criterion for satisfactory welding, it has been found that a very slight curvature, that is, a small difference in expansibility, indicates that the glasses will weld together without subsequent fracture, if well annealed. If the strip is absolutely straight there is no doubt that the two glasses may be used for any type of cased ware or for blowing even the most delicate apparatus before the blast lamp. A curvature of any appreciable amount, however, means that a satisfactory product can not be made of the glass combination.

Although the most frequent use of a test of this sort would doubtless be to determine whether or not two glasses had the same expansibility without regard for the amount of this expansibility, still the method can be made a quantitative one in a very simple manner.

A number of glass rods of small diameter and known expansion coefficients are obtained, ranging in value from 0.0000030 to 0.000011 by steps of about five in the seventh decimal place. This requires about sixteen or more different glasses. A suitable rack or tray should be provided and properly labeled so that easy access may be had to each variety.

If it is desired to determine the expansion coefficient of a new glass, a sealing test such as has been described above is made on the sample, using as a standard the one of the glasses of known expansibility which the experimental glass is judged to be most

nearly like. From the result of this test the operator can easily tell in which direction the expansibility of the new glass lies, and a different standard is tested against it, until two known samples are found, one of higher and one of lower expansibility than the unknown. It now becomes easy to estimate within one or two units in the seventh decimal place, what is the coefficient of the unknown glass. By pulling the strip out rapidly into a fine thread the delicacy of the test is much increased and the method becomes very accurate.

The use of this method involves neither delicate apparatus nor a skilled operator, but may be used by a novice with almost no experience with a blast lamp. The standards must of course, be obtained by direct measurement or from a factory in which the expansion coefficients of the glasses have been accurately determined by careful laboratory methods.

In employing this test for factory control and laboratory experimentation in the several years it has been in use by the author, he has never been disappointed by obtaining misleading results. Several times actual measurements have been made to confirm the values arrived at by this method and in no case have the two methods failed to agree.

In conclusion, the author would like to express his thanks to Dr. J. T. Littleton of the Corning Glass Works, who very kindly permitted the publication of this article.

HAMBURG, N. Y.

THE DESIGN AND OPERATION OF GLASS HOUSE FURNACES*

By F. J. Denk

ABSTRACT

Design and operation of glass house producer-gas furnaces.—After discussing the proper design of checker chambers, two inefficient designs are criticised. The gases being cooled should move downward and the gases being heated should move upward, and the dimensions should be based on actual working data. The location of the ports is important and heat insulation should be carefully considered. The reversing valve should be efficient and operated regularly; and the performance of the furnace should be constantly watched with the help of instruments such as draft recorders and thermocouples, and the waste gases should be analyzed frequently. With care in design and operation it should be possible to approach the performance of a certain furnace which gave 3 lbs. of glass for each pound of coal burned.

Many of the present pot furnaces and tanks have been built with the intention of using mainly natural gas, but provision has been made for the application of producer gas, by including a set of gas regenerating chambers to take care of the new fuel. The arrangement is, in many cases, made in such a way, that the preheating chambers are used for the air as long as natural gas is applied, while the other set of chambers is closed up.

As the regenerating chambers form one of the most important parts of a furnace, something may be said about their design and layout.

The capacity of the regenerating chambers is too often inadequate for the conditions under which they are supposed to work. This may be due to the application of an old "rule of thumb" method in designing the chambers, a method which was all right, as long as only natural gas had to be dealt with, since this gas, being practically of uniform pressure, temperature, and composition, always required the same quantity of air. Conditions, however, are different with producer gas. When laying out a plant and designing a furnace for this fuel, careful attention should be paid

* Received February 7, 1921.

to the conditions, under which the gas enters the checker chambers. The temperature and composition of this gas are important factors in the design. Needless to say, the designer can not take care of irregular operating conditions due to carelessness or ignorance on the part of the operators; for instance, in the gas producer plant. On the other hand, he should not assume best possible working conditions, because they may happen only once in a long while. The designer must know, therefore, what can be expected from a certain class of laborers, from a certain type of gas producers, and from a certain grade of coal, and this knowledge will give him enough points for his calculations.

The design is correct, when the desired furnace temperature can be obtained and maintained. In order to have a uniform temperature all over the hearth, it is necessary to provide for a uniform progress of the combustion reactions. This condition can be obtained by giving those gases, which are not yet completely consumed, a chance to burn completely, by adapting the combustion space to the existing conditions, and by forcing the highly heated gases of combustion to heat the bath or the pots in the most efficient manner.

The arrangement of the checker chambers should be such that the currents of hot gas, which are supposed to heat the cooler bricks uniformly, must flow in a downward direction, whereas the currents of cold gas, which are supposed to cool the hotter bricks and attain a higher temperature themselves, must flow in an upward direction.

The reason for such an arrangement is evident. The hot gases entering at the top will give up their heat to the colder bricks, thus becoming cooler the farther down they travel. But the cooler the gases, the heavier they will become and the result is a natural descent of the waste gases in the direction of the outlet, *i. e.*, towards the stack connection. The opposite will take place after the valves have been reversed, that is, cold gases will enter the chambers on the bottom and, coming in contact with the hot bricks, they themselves become hotter, expand, become lighter, and rise.

In this connection a few remarks about the height of the furnace stack may be made, which have a bearing on the conditions ex-

plained in the preceding paragraph. It is sometimes stated, that on account of the hot gases being forced downward through the checker chambers, an additional height must be provided in the stack to overcome the natural tendency of the hot gases to move upward. This statement is, as explained above, not correct, because if the checkers are laid out in the manner indicated, the natural passage of the gases will be downward; the height of the stack should, therefore be figured from the point, where the gases leave the chambers, *i. e.*, from the bottom.

The chambers should be grouped as far as possible in one block, in order to reduce the radiation losses to a minimum. For the same reason the walls should not be less than 18″ thick, unless, of course, local conditions should interfere. The partition walls should be of the same thickness to prevent leakage through them, which would cause gas and air to mix and to burn in the chambers instead of in the furnace. Here, too, local conditions may forbid the erection of walls of such thickness, but in such cases they should be built with the utmost care, the bricks being laid in a good cement and coated with a gas tight surfacing material.

To prevent radiation losses as much as possible, the chambers and uptakes should be covered with a good insulating material, wherever the walls are exposed to the outside air. On the furnace proper, care must be taken not to go too far with the insulation. On a tank, for instance, the lower part should never be covered, because there would be danger of the molten glass eating up the side blocks, thus destroying the hearth. Of course, to leave the sides uncovered means a heat loss, but this loss can not be prevented except at the sacrifice of the whole tank.

The best thermal efficiency will be obtained with chambers having the longer axis vertical. They should be arranged so that as much of the checker work can be utilized as possible and the formation of "dead pockets" is eliminated. It is hardly ever possible, on account of practical considerations, to give the chambers a theoretically perfect form. It should, however, be the aim of the designing engineer to try to follow those theoretical outlines as much as he can in order to prevent dead pockets and, therefore, unnecessary waste. The main disadvantage of hori-

zontal chambers lies in the resistance which they offer the unobstructed flow of the gases.

The accompanying sketches of checker chambers illustrate certain incorrect methods of design which are sometimes found in practice.

Figure 1 shows a rather common arrangement of the air and gas chambers for an end port tank. The general design of the chambers is nearly vertical, and should give a good utilization of the available heat, but this advantage is offset by the arrangement of the inlets and outlets for gas and air. The location of the gas inlet is nearly correct although it might, to advantage, have been flared out so as to cover the whole width of the chamber. The gas outlet; however, is in the wrong place, leaving the gas chambers along the partition wall instead of being flared out and reaching over the whole top. The result is a dead pocket opposite the outlet. Conditions are worse in the air chamber. Here the inlet is located in the elongation of the partition wall and the outlet is almost vertically above it, thus making a dead pocket out of about three quarters of the volume of the chamber. An arrangement of this kind, is, of course, entirely wrong.

But the location and arrangement of the uptakes as shown must be objected to for another reason also. The hot gases, coming with a high velocity from the furnace, impinge with full force against the bricks. They are then reflected and form eddy currents along the crown, thus making impossible a uniform working of the chamber. The latter can only be obtained when the velocity of the waste gas currents in the space between checker bricks and top of the chambers is reduced to zero or at least to nearly zero. A simple method of doing this is to increase gradually the sectional area of the downtakes, or, in other words, to flare them out from a certain distance above the chamber to the crown. This flaring out can be done on all four sides, thus giving the uptakes the form of the frustrum of a pyramid. The insertion of a slag pocket will answer the same purpose, but for lack of space such slag pockets are not very often found on tanks. On pot furnaces, slag pockets can easily be provided for on the bottom of the eyes, the gas and air connections to the chambers being taken off a little distance below the bench. In order to prevent

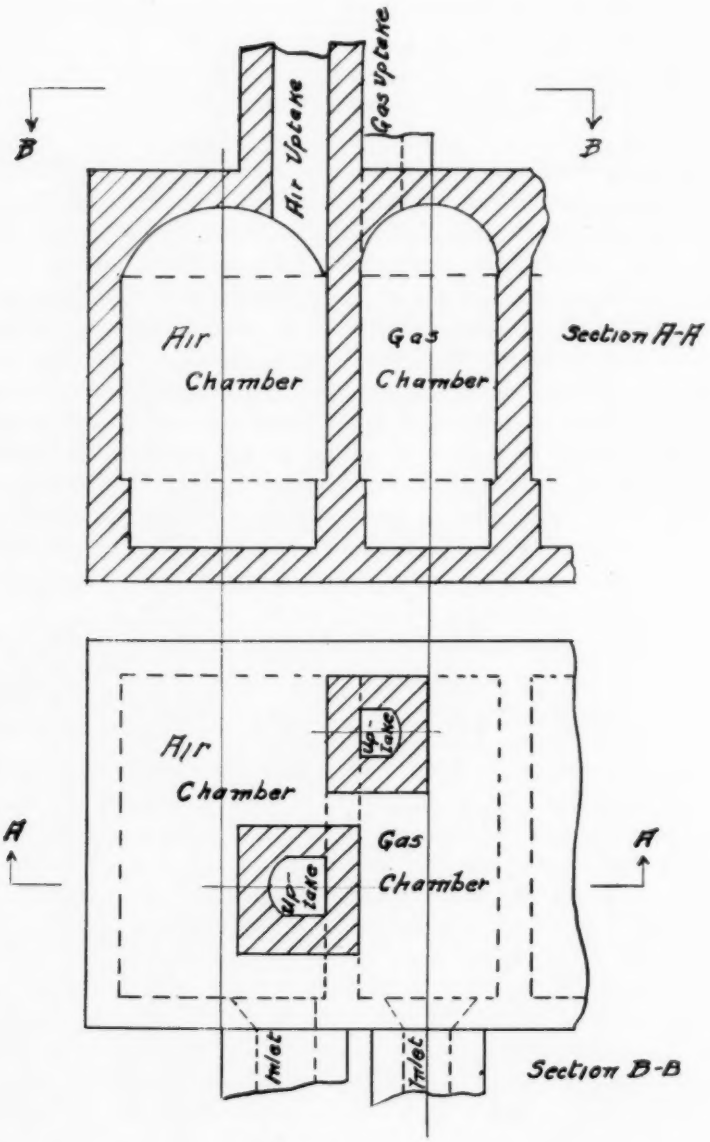

B
B
Air Uptake
Gas Uptake
Air
Chamber
Gas
Chamber
Section A-A
Air
Chamber
Up-take
A
Gas
Chamber
Up-take
A
Inlet
Inlet
Section B-B

FIG. 1.

molten glass from a broken pot running down into the chambers through the ducts, provision is made on top of the openings to divert the flow of the molten glass and force it to drop or run down into the pocket, whence it can be removed without disturbing the working of the furnace. Such an arrangement is shown in figure 2, the arrows indicating the flow of the molten glass.

Figure 3 illustrates another arrangement of vertical chambers, which is inefficient, and wrongly designed. Here the gas currents are forced, by means of vertical partition walls, alternately

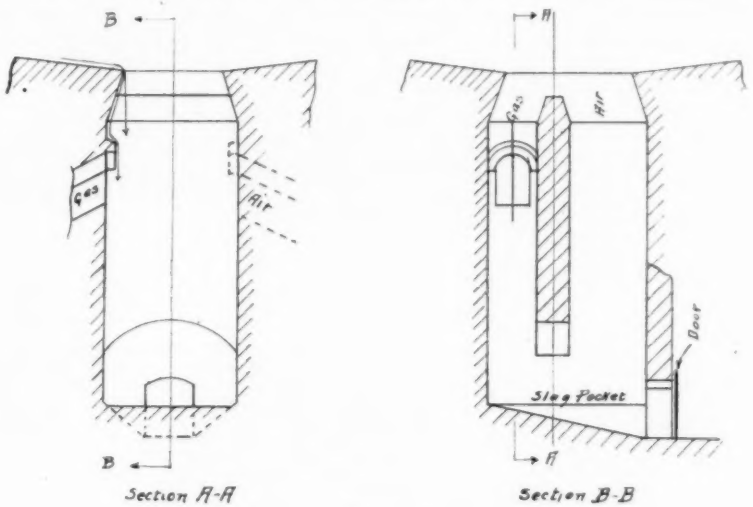


FIG. 2.

downward and upward. When coming from the furnace the gases enter the chamber on the top and travel downward, as they should do. But after having passed through half of the checker space, their direction is reversed and they are forced to flow upward, against their natural tendency, which would be to continue in a downward direction, since they are becoming denser and therefore heavier, the farther they travel. Thus a pocket filled with hot immovable gases, will be formed on the bottom below the bricks, which will prevent the regular working of the checker chamber.

Horizontal chambers, *i. e.*, chambers, having the longer axis

horizontal, are seldom found in glass plants. It is true, the chambers of side port tanks are horizontal in form, but they are actually vertical chambers, because the outlets are on the top and furthermore, the chambers are often subdivided into compartments having a common flue along the bottom. They work, therefore, entirely like vertical chambers and, when the uptakes are arranged along the division walls between the chambers as shown in figure 1, labor under the same disadvantages as the vertical ones.

It was stated above that as a rule the volume of the checker chambers is too small, due perhaps to the application of an old "rule

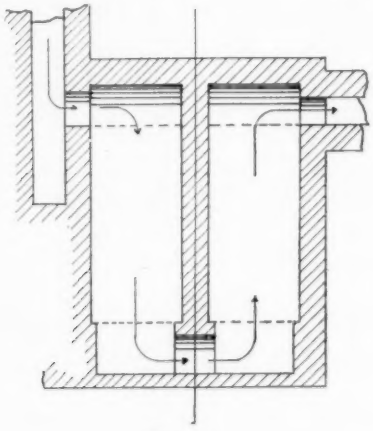


FIG. 3.

of thumb" method of designing. The same holds good for other parts of the furnace. The design of gas and air flues, uptakes, ports, etc., has mostly been guessed at, and no one has taken the trouble to check the actual conditions, chiefly in regard to actual velocities. Thus it happens, that widely varying data can be obtained from different furnaces or other appliances of the same size and type. Here lies one of the main uncertainties in the design of glass house furnaces. I have investigated this matter carefully and have collected a set of data in regard to temperature, pressure and velocity of gas and air in the different parts of a furnace, which I have applied with good success to new installa-

tion and which have shown me, that "guesswork" or "rule of thumb" methods can be and must be avoided, if we want our furnaces to work economically and satisfactorily. To show the fallacy of such methods in a somewhat exaggerated case, I may mention the following.

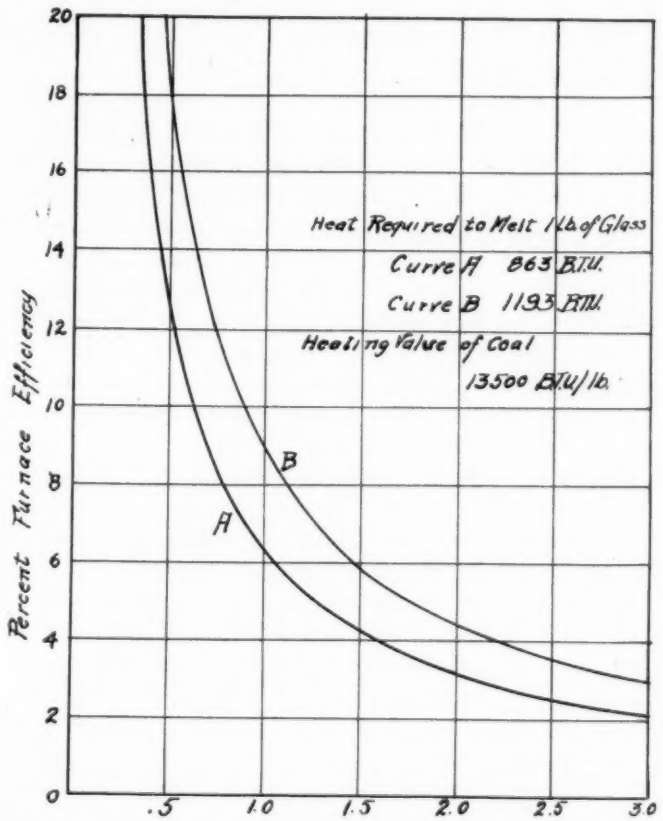


FIG. 4.—Lbs. of coal per lb. of glass. Ratio between furnace efficiency and quantity of fuel used.

There is a rule used by the designers, which makes the area of the ports equal to a certain percentage of the area of the hearth. Now supposing the hearth area of an endport tank is to be 400 square feet in the melting end, would it be good practice to make

the port areas the same irrespective of whether the hearth were square or rectangular? Certainly not, because if the area were correct for the square hearth, it would be too large for the rectangular hearth, for the reason that the gases emanating from it would not have force enough behind them to travel around. This shows how cautiously these rules should be handled. It is best to disregard them altogether and to base the calculations on good working practice.

Similar conditions can be found in the hearth. The distance between the top of the metal and the crown should be such that for a given width and a certain velocity of the gases the sojourn of the hot gases is timed to give the best possible utilization of the heat. We must keep in mind that heat is not transmitted to our furnaces by radiation, notwithstanding a widely spread belief to the contrary, but mostly by convection or contact between the hot gases and the bath and this heat transmission will be the better, the higher the temperature difference. For this reason, the gases must remain over the bath long enough to enable them to give up their heat to the molten glass. If the vertical area of the hearth is too small, the gases will carry part of their useful heat into the stack, and if the vertical section of the hearth is too large, the velocity of the hot gases will be reduced considerably—in extreme cases even to zero—and they will follow their natural tendency to rise, thus heating the crown instead of the bath.

We must keep in mind also that our furnaces are working with a low efficiency for this reason. Everything possible should be tried to improve operation and reduce the preventable fuel losses to a minimum. Figure 4 shows two curves, illustrating the relation between furnace efficiency and quantity of fuel consumed. Curve A represents a glass requiring 863 B. t. u. per pound, and curve B a glass requiring 1193 B.t.u. per pound. These two figures represent approximately the limits of average practice, with the exception of certain special melts. The worst condition that has come under my observation, is an oil fired furnace, requiring an equivalent of 2.6 pounds of coal per pound of glass. This corresponds to about $2^1/_4$ per cent efficiency for curve A, and to about $2^3/_4$ per cent efficiency for curve B. The best performance encountered was equivalent of $^1/_3$ pound of coal per pound of

glass. It was found in the case of a producer-gas fired side port tank, giving an efficiency of over 20 per cent. It is hardly possible to excel this performance with our present type of furnaces, but there is no reason why it should not be approached more closely than is usually the case. A glance at the curves will show that from about 1.5 pounds of coal down, a slight reduction in

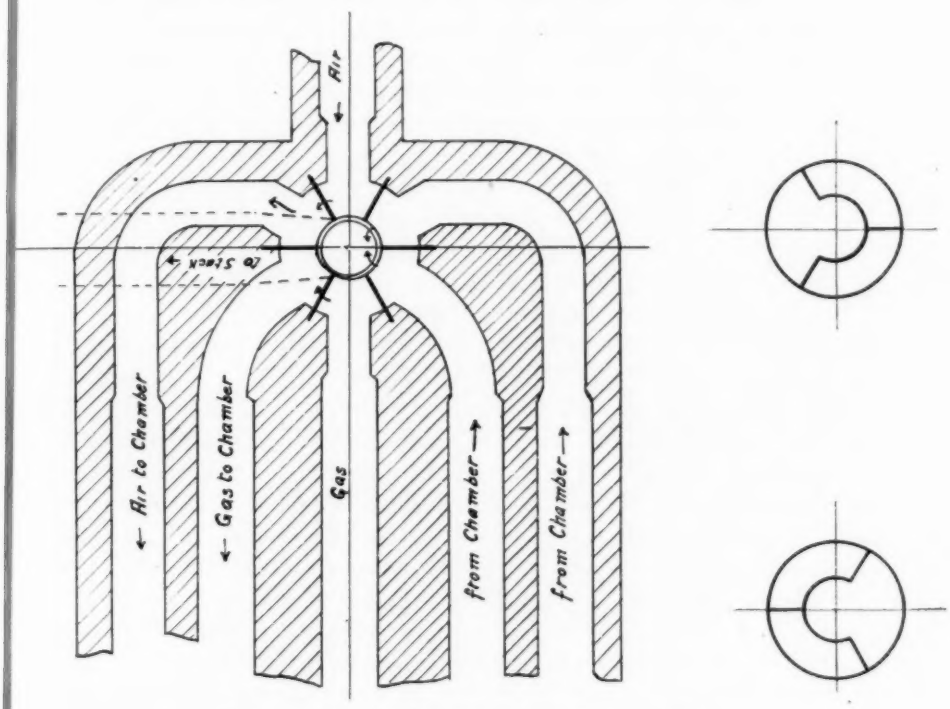


FIG. 5.—Combination gas and air-reversing valve.

fuel will increase considerably the efficiency of the furnace. Such a reduction can be obtained, (1) by a correct design of the chambers and the furnace as explained above, and (2) by careful selection and arrangement of the proper auxiliaries.

The gas flues between producer and furnace should be covered with a good insulating material, unless they are laid under ground. This is not very important for the working of the furnace, be-

cause the heat lost by radiation in uncovered mains will be regained in the checker chambers, but it makes a big difference whether the gas enters the chambers at say, 1300°F or at only 700°F. In the first instance, the gas chambers can be made much smaller than in the second, thus saving space and reducing

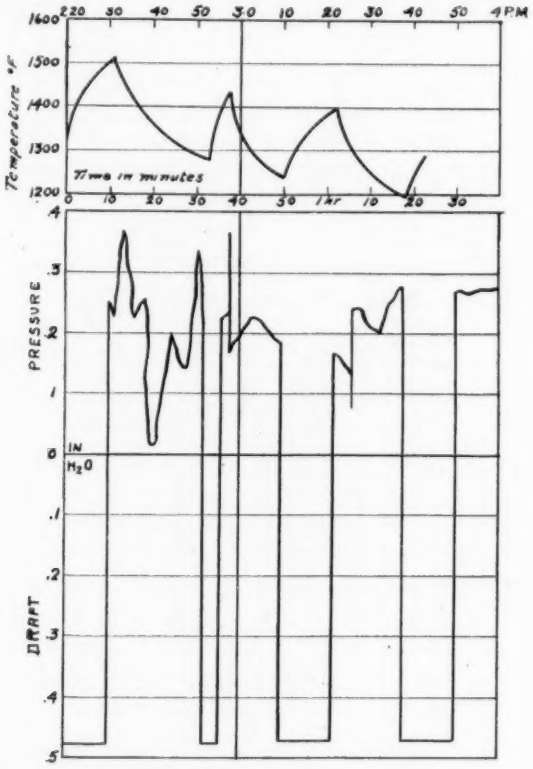


FIG. 6.—Chart showing influence of reversals on temperature of checkers.

the radiating surface. Furthermore the heat not used in the checker chamber can be utilized in waste heat boilers to generate the steam for the producers. Thus, although there is no direct influence on the working of the furnace by covering the lines, the indirect influence is of considerable importance and should not be neglected.

Another item to be watched carefully, is the selection of a good type of reversing valve. If this is not attended to, a loss of gas will occur which may amount to as much as 3 per cent or more. The best type, however, will work inefficiently, if reversing can not be done in the shortest possible time. A short lever arrangement is the best for this work. Hand wheels should never be applied as they result in a large loss of gas up the stack.

A very inefficient type of a reversing valve is shown in figure 5. It is a combined gas and air valve, designed to save space. It does save space but efficiency is sacrificed. The upper part shows a layout of the valve with the corresponding gas and air ducts and the stack connections, while below are shown two horizontal sections of the valve proper illustrating the two positions. Besides a large loss of gas during reversal, there is a possibility of frequent explosions which may damage the whole arrangement.

A few words may be said about the operation of the valves. Irregular reversal means irregular working of the furnace. Figure 6 illustrates the influence of irregular reversing on the temperature of the checker chambers. The lower part of the curves is obtained by means of a recording draft gauge, located between the chambers and the valve whereas the upper curve is plotted from observations made with a pyrometer in the checker chamber. It can easily be seen that the short periods during which the chambers are connected to the stack cause a decided drop in the temperature of the checkers, which, in turn, will have a decided influence on the working of the furnace. Regular reversals will prevent such occurrences.

To get the best possible operation of a given furnace, it should be under constant observation. This can be done only by means of suitable instruments, located at the right places.

In the first place, draft recorders should be employed, which enable the operator to control the working of the chamber. Clogging of the bricks can be detected in this way and unnecessary fuel losses followed by too high stack temperatures, can be prevented. The temperatures of the furnace chamber and stack should also be under constant observation, which may be done by a switchboard suitably arranged to show the temperatures at the different points. In the furnace and in the chambers a platinum-platinum-

rhodium couple must be employed, while in the stack a base metal couple can be used. Care must be taken to protect the platinum-platinum-rhodium couple from direct contact with hot gases, because they make the platinum brittle and thus ineffective. Finally, regular analyses of the waste gases should be made in order to ascertain whether combustion is complete or not. Such analyses are easily made and do not require a large and costly outfit.

If the rules laid down and explained above are followed, there is no reason why we should not be able to secure an efficient and satisfactory working of our furnaces.

PITTSBURGH, PA.

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by cooperative agreement.

General and Miscellaneous

1. **Reorganization of instruction in ceramics.** REISENEGGER, Berlin-Dahlem. *Ber. d. Tech.-wiss. Abt. d. Ver. keram. Gewerke.*, **5**, Pt. 5, 4–7 (1919).—A plea is made for the establishment of ceramic instruction and research in the technical high schools to enable Germany to regain its world supremacy in the markets for ceramic products. E. N. BUNTING.

2. **The ceramic industries.** EDWARD W. WASHBURN. Univ. of Ill. *Tech. Eng. News*, **1**, No. 8, 1 (1920).—A brief discussion of the field covered by the ceramic industries, their importance in modern life, the need of research, and the opportunities which exist for the technically trained man in this industrial field. Ed.

3. **Transferring designs to ceramic ware.** WILHELM SCHERTEL, Selb. *Ber. d. Tech.-wiss. Abt. d. Ver. keram. Gewerke*, **5**, Pt. 5, 34–40 (1919).—Methods of transferring ornamental designs and pictures to ceramic ware are described. Usually the lithographic method is used, although relief printing is also practiced. Many problems in this field await solution E. N. B.

4. **The mechanical properties of ceramic bodies and methods of measuring them.** ERNST ROSENTHAL, Selb. *Ber. d. Tech.-Wiss. Abt. d. Ver. keram. Gewerke.*, **5**, Pt. 5, 23–33 (1919).—Methods, with photographs, of determining the resistance of bodies to pressure, torsion, bending, tension and sudden blows, are given. These mechanical properties depend greatly upon the structure of the material and the degree of vitrification. More attention should be given to the measurement of these mechanical properties and to their dependence on the composition, structure and heat treatment of the bodies. E. N. BUNTING.

5. **Instruction in ceramics in the technical high school at Charlottenburg.** ANON. *Ber. d. Deut. Keram. Gesell.*, **1**, Pt. 1, 38–40 (1920).—Instruction and research under Dr. R. Rieke is now being carried on and the establishment of a separate department of ceramics is contemplated. E. N. BUNTING.

PATENTS

6. **Drier for clay or ceramic products.** ITHAMAR M. JUSTICE. U. S. 1,360,645, Nov. 30, 1920.—The combination consists of drying tunnels having receiving and delivering ends, means for moving the product through the tunnels, fuel tunnels extending beneath the drying tunnels, a stack connected to the fuel tunnels, channels communicating with the stack and with the drying tunnels and air inlets for the receiving ends of the drying tunnels, whereby air introduced into the drying tunnels at the receiving ends thereof will be gradually increased in temperature as it passes through the drying tunnels.

7. **Pottery-ware.** ARTHUR PERCY MORRIS. Insein, Burma, India. 1,362,-956, Dec. 21, 1920.—The process for figuring "Burmese black" pottery, consisting in removing the carbon blackening by oxidiaton thereof, over a predetermined area, to reveal the natural color of the clay. C. W. SAEGER, JR.

Apparatus and Instruments

8. Prize awards of the German Ceramic Society. M. HEINE. Bonn. *Ber. d. Deut. Keram. Gesell.*, **1**, Pt. 1, 7–23 (1920).—Due to shortage in cotton cloth during the war, prizes were offered in 1918 for new methods of preparing clay slips, using little or no filter cloth. Centrifuge methods were found, useless, as the constituents of a mixture separate and the resulting mass is not homogeneous. Suction filters also could not be used, as only a thin layer separates which becomes so dense that the process soon stops. The electro-osmosis process was too expensive and could not be installed in a short time. First prize was awarded a filter press apparatus using thin metal discs clamped together as filter plate. Second prize was given to a filter cloth of specially woven paper material. Third prize, porous plates made of porous material, one of coarse grained, another of fine grained structure, usable in ordinary forms of filter presses. Fourth prize, the method of sieving and dry grinding before mixing with a suitable amount of water in a pug-mill. Other methods, some of which are continuous could not be considered because they could not be used for lack of coal. The methods submitted are grouped into eleven divisions. E. N. BUNTING.

9. Ceramic applications of the electrosmosis process. FELIX SINGER. Selb. *Ber. d. Tech. Wiss. Abt. d. Ver. keram. Gewerke.*, **5**, Pt. 5, 16–22 (1919).—A kaolin is obtained by this process of much higher purity than the usual washed kaolin, and its use in a body insures freedom from casting flaws, caused by the impurities, principally mica, in ordinary purified kaolin.
E. N. BUNTING.

10. A sensitive method of thermal analysis, and the transformation points of quartz, of iron, and of nickel. ALBERT PERRIER AND F. WOLFERS. Lausanne. *Arch. sci. phys. nat.*, **2**, 372–81 (1920).—The method employs the differential thermocouple but avoids the necessity of employing a second material as comparison or reference substance. Instead, two samples of the material under investigation are used, being placed at different levels in the furnace so that one lags about 10° behind the other on heating or cooling. Both the differential couple and the temp. couple are connected to a recording chronograph. The method is rapid (20°–60° per min.) and sensitive. The α-β-trans. temp. of quartz was found to be 570°. (Cf. Perrier, *Ibid.*, (4) **46**, 45 (1918). LOUIS NAVIAS.

Refractories and Furnaces

11. Physical characteristics of refractories. I. Spalling losses. II. Cold and hot abrasion tests. M. L. HARTMAN AND O. A. HOUGEN. *Trans Am. Electrochem. Soc.*, **36**, preprint (1920); cf. *C. A.*, **14**, 2246.—I. Comparative tests were made on 12 different kinds of refractory bricks purchased in the open market, exposed to rapid cooling, in an air blast, from a temp. of 1350°. Three of these kinds were completely disintegrated at the 7th, 4th and 3rd treatment. The others were treated 10 times. The three

bonded carborundum varieties showed the least spalling (under 8%). Chrome brick was all gone after the 7th test, silica after the 4th, and magnesia after the third. II. A carborundum cutting wheel was used for the hot and cold abrasion tests and the abrasion in a given time, under equal pressures, noted. Again the bonded carborundum gave the best results. In discussion, it was brought out that this test was probably very much affected by differences in heat cond. W. E. RUDER. (*C. A.*)

12. **Heating of retort settings. Some theoretical considerations in the design of gas works plant.** G. DOUGILL. *Gas J.*, **152**, 454–6 (1920); *Gas World*, **73**, 428–9 (1920).—The vertical retort lends itself most readily to efficient heating, the horizontal retort is most difficult, and the coke oven occupies an intermediate position. The efficiency of the horizontal retort is reduced by the supporting walls, and it is proposed that thinner walls at shorter intervals would produce better heating without diminishing the mechanical strength. In horizontal-retort plants where outside producers are installed, it would be well to follow coke-oven practice and build the retorts in vertical lines and the combustion chambers at each side of the retort with recuperators. J. L. W. (*C. A.*)

13. **The development of the refractories industry in general and especially during the last war.** H. GEYER. MARKTREDWITZ. *Ber. d. Deut. Keram. Gesell.*, **1**, Pt. 2, 33–45 (1920).—Production of ceramic material has doubled since 1900. The present output is about 1,000,000 tons, which is only $^2/_3$ normal. There are one hundred factories and they employ 35,000 workers. 250,000–300,000 tons of coal are used annually. The business statement of the United Chamotte Factory of Marktredwitz, whose annual production is about 25,000,000 kgs. follows: Raw material 15.1%; Coal 9.7%; expense of operating machinery, 4.7%; wages 25.4%; operating expenses, 8.6% sales expenses, 15.8%; of which 5.4% is for salaries; warehouse costs 7.9%; gross profit, 12.8%, total 100%. E. N. BUNTING.

14. **Utilization of the ash from ceramic kilns.** M. SAUER. Augsburg. *Ber. d. Deut. Keram. Gesell.*, **1**, Pt. 2, 48 (1920).—The ash from a kiln fired with a mixture of wood and coal had a heating value of 2120 Cal/kg. and could be used in heating boilers. Slag and dirt must be removed by sieving before use. E. N. BUNTING.

15. **The utilization of heat from cooling kilns.** R. RIEKE. *Ber. d. Deut. Keram. Gesell.*, **1**, Pt. 1, 36–8 (1920).—Fuel can be saved by using the heat from cooling kilns to warm working rooms or drying rooms. A system of pipe lines leads the hot air from the kiln to the rooms and where several kilns are used, a considerable saving in fuel is obtained. E. N. BUNTING.

BOOK

16. WILHELM BORCHERS. **Die elekttischen Oefen.** WILHELM KNAPP. Halle an der Saale, Germany. 1920. 289 pp. 443 illus. 3rd enlarged edition.

PATENTS

17. Kiln. FRANCIS FIDLER. U. S. 1,364,090, Jan. 4th, 1921.—A tunnel and a car kiln having a cooling zone and a drying tunnel, the walls of the cooling zone having ducts closed against the zone but with portions open to the heat of the zone of relatively high heat conductivity, and a means of communication between the ducts and the interior of the drying tunnel.

18. Electrically-heated crucible, melting-pot, and the like. CHARLES WILLIAM SPEIRS. U. S. 1,366,135, Jan. 18, 1921.—The combination with pourer element, of electrical terminals at each end of the crucible and an electrical terminal fitted to the outer end of the pourer element, from which current can pass through the element to either or both of the main crucible terminals.

19. Refractory Furnace. WILLIAM JEFFREY HILL. Montreal, Canada. 1,363,787, Dec. 28, 1920.—A furnace structure comprizing a heat accumulating and radiating element having tortuous passages therethrough by the arrangement of fire-brick transversely and longitudinally, a deflecting slab surmounting the fire-brick centrally and extending longitudinally from end to end, a vertical longitudinal central wall on the slab, brick walls inclosing the element and forming an oven thereabove and having central and side ledges from the interior wall level with the vertical central wall, and a hydrocarbon burner emitting a flame into the oven.

20. Abrasive and refractory article and method of producing same. ALBERT H. ANDERSON. U. S. 1,364,849, Jan. 4, 1921.—A combination of matter for forming ceramic articles comprizing refractory or abrasive crystalline grains, a plastic clay, water and an oily lubricating agent.

21. Surface-combustion furnace. FRANZ J. DENK. U. S. 1,365,769. Jan. 18, 1921.—A surface-combustion furnace, a chamber, a zone to be heat in the chamber, spaced refractory material at a side of the zone, means dividing the material into a series of sections, separate means for supplying combustible gaseous fuel to the material in each section and separate means for controlling the flow of the fuel to each section and means for drawing the products of combustion away from, and out of contact with, the articles being in the chamber.

22. Heat resisting cement. HAROLD S. ASHENHURST. U. S. 1,365,077. Jan. 11, 1921.—A new composition of matter composed of finely divided asbestos having weight of twenty-five to fifty pounds per cubic foot, a water-soluble salt, and water, combined as set forth.

23. Refractory material. LOUIS DENIS. Liege, Belgium. 1,365,230. Jan. 11, 1921.—Porous, refractory material consisting of a mixture of pure, rich refractory earth, poor earth, magnesia, and saw dust, heated to a temperature sufficiently high to consume the saw dust and thereby render the product porous.

24. Refractory article and process for making same. FRANK J. TONE. U. S. 1,362,274, Dec. 14, 1920.—As a new article of manufacture, a highly refractory material consisting essentially of a burnt mixture of zirconia sillimanite.

25. Refractory article and process for making same. OTIS HUTCHINS. U. S. 1,362,317, Dec. 14, 1920.—A shaped highly refractory article formed of a burned mixture containing zirconia and chromide.

26. Crucible smelting-furnace. CHARLES M. STEIN. Paris, France. 1,365,204, Jan. 11, 1921.—A crucible smelting furnace particularly intended for the smelting of glass or crystal, having a central gas burner, a crucible chamber arranged centrally above the burner comprizing a series of uniformly spaced hollow arches, a regenerator for heating the air supplied to the burner, flues connecting the regenerator with the hollow arches, and flue openings carried by each arch, opening into the arch flues for establishing a return circuit for the hot flames and gases entering the crucible chamber.

27. Refractory material and process of making it. OTIS HUTCHINS. U. S. 1,362,316, Dec. 14, 1920.—As a new article of manufacture, a highly refractory material consisting essentially of a burnt mixture of zirconia and alumina.

C. M. SAEGER, JR.

Chemistry, Physics and Geology of Raw Materials

28. New modification of silicic acid. ROBT. SCHWARZ AND OTTO LIEDE. *Ber.*, **53B**, 1680–9 (1920).—By hydrolysis of SiF_4 in boiling water, opaque, non-gelatinous scales were formed which, after dialyzing 8 days, contained 95% water and differed little from the product obtained by hydrolysis of SiF_4 at 0° in appearance or rate of dehydration over H_2SO_4. The chem. conduct of the first (*b*-acid) product was found to be entirely different from that of the second (*a*-acid); 1 g. of the latter with 95% water content dissolved in 1% HF in 9 min., while 1 g. of the former with the same water content required 36 min. The *b*-acid adsorbs practically no methylene blue, while the *a*-acid removes it almost completely from soln. In 5% NaOH the *b*-form showed much lower soly. than the *a*-form, both for water-rich and water-poor prepns. In 3 *N* NH_4OH the Q value did not exceed 25 even in 49 days, and this value was reached only with water-rich, fresh prepns.; aged or water-poor prepns. gave about 15. The *b*-acid is concluded to differ from the *a*-acid in the larger size of the primary particles and in giving, upon soln., a more highly polymerized polysilicate. The analogies between these two forms of silicic acid and the two forms of stannic acid (Mecklenburg, *C. A.*, **6**, 1720) are very marked. Surprisingly, hydrolysis of $SiCl_4$ at 100° gave a product showing all the properties of the *a*-acid and with a value of Q = 48 in a gel 14 days old.

A. R. MIDDLETON. (*C. A.*)

29. The dynamics of capillary flow. EDWARD W. WASHBURN. Univ. of Ill. *Phys. Rev.*, **17**, 273 (1921).—If a porous body behaves as an assemblage of small cylindrical capillaries, then if it be immersed in a liquid, the rate of

penetration, dv/dt, of the liquid into the body is proportional to the square root of the ratio, γ/η, of the surface tension of the liquid to its viscosity and inversely proportional to the time of soaking, t, *i. e.*, the volume, V, of liquid which penetrates the body at the end of the time t, is given by $V = k\sqrt{\gamma/\eta t}$. The theoretical deductions are confirmed by experiments.—Ed.

30. The internal friction of quartz filaments at high temperatures. C. E. GUYE AND A. MOREIN. Geneva. *Arch. sci. phys. nat.*, **2**, 351–71 (1920).—With respect to torsional friction fibers of quartz and glass behave differently than those of metals. At low temps. C. E. Guye and M. Einhorn (*Ibid.*, **41**, Apr., May and June, 1916) have shown that the logarithmic decrement (λ) for fibers of quartz and glass is practically independent of the amplitude of oscillation, which is not the case with metal fibers. In the present report, a description and sketch of app. used for quartz threads 23 cm. long are given. The suspended threads were allowed to oscillate, under various conditions and the consecutive amplitudes were recorded photographically. Measurements were made at temps. from 18° to 325°. The authors conclude that the internal structure of quartz changes on annealing in such a way that λ increases (at 20° for fibers 0.580 mm, λ before annealing = 0.00943, after annealing 0.01352). The change of λ with temp. depends upon the diameter of the fiber, the smaller the diameter the higher the temp. of minimum λ (120° for fiber of diameter 0.654 mm., 200° for diameter 0.208 mm.). It was not possible to obtain a "normal state for annealed quartz," *i. e.*, independent of the diameter of thread. It was found that λ is practically independent of the amplitude and of the moment of inertia of the oscillations. It is conjectured that with proper annealing it should be possible to render fibers of all diameters identical as far as structure is concerned. The results for quartz are in general analogous to those obtained for a Jena glass by C. E. Guye and S. Vassileff (*Ibid.*, March and April, 1914). LOUIS NAVIAS.

31. Arc images in chemical analysis. WM. ROY MOTT. *Trans. Am. Electrochem. Soc.*, **37**, preprint (1920).—A new method of chem. analysis has been formulated, which consists in bringing the materials to be tested into or under the influence of the carbon arc in a special manner. Full details are given. The major analytical resources of this method consist in: (*a*) Characteristic modifications in the appearance and behavior of the arc stream, and of the carbon craters. (*b*) The order of distn. of the materials under the influence of the heat of the arc. (*c*) The character, color, position and form of the distn. deposits upon the upper and lower electrodes, and the character of the residues. Also specific modifications of these appearances by addition of suitable reagents. (*d*) The application of ordinary analytical reactions to the deposits and residues after decompn., distn., or sepn. by the arc. The method has unique advantages in the analysis of all *refractory materials*, minerals and compds. the decompn. of which is most troublesome and tedious by the usual methods of analysis. The method has specific analytical advantages in the case of many of the less common elements, and of those offering

special difficulties by present methods. It is of particular value in the case of the following elements: F, P, Cd, Zn, Ag, Au, Na, K, Ba, Ca, Sr, Mg, B, Be, Al, Ti, Zr, V, U, Cb, Mo, Ta, W, and the rare earth elements. The method is least applicable to the non-metallic elements. It is unavailable for acid radicals and org. compds. The delicacy of test ranges from 1/50 mg. for Ag, Au and W, to 1/10 mg. for S, P, Cd, Pt, Cr, V, Ti, U, Yt, Zr, Th, Cb, Mo, and Ta. Most of the other elements can be detected in amts. of 1 mg. The major constituent of any mineral, alloy, refractory or chem. ppt. can be readily identified in less than 10 min. Distinctive tests and analytical procedure for 65 elements are outlined. C. G. F. (*C. A.*)

32. The conduct of electrolytic ions in solid bodies. II. Dissociation relations in permutite. A. GÜNTHER-SCHULZE. *Z. Elektrochem.*, **26,** 472–80 (1920); cf. *C. A.*, **14,** 678.—The electrolytic cond. and the change in mol. vol. of K-Cd, K-Pb, Li-Cd and K-Cr permutite mixts. have been measured. (*C. A.*)

33. Economic minerals of Madagascar. GEORGE F. KUNZ. *Eng. & Min. J.*, **111,** 14–18 (1921).—The widespread *graphite* deposits occur in crystalline schists which have been superficially altered to a lateritic clay. The graphite is of excellent quality and being free from sulfides and $CaCO_3$, is suitable for crucibles. The production reached a maximum of 35,000 metric tons in 1917 but since then has dropped. At present graphite having a 80% carbon content is quoted at 850 fr. per ton in Marseilles. *Corundum* also occurs in these lateritic clays. Gem material is rare but there is a considerable production of material for abrasive use. Production started in 1910, and in 1919, 812 metric tons were exported. It is estimated that a production of several thousand tons can be developed. The price is quoted as 750 to 800 fr. per metric ton in Marseilles. There are also notable deposits of *zircon*. *Zircon* crystals 15 cm. long have been found. D. D. SMYTHE.

34. Biennial report of the state geologist of Missouri. H. A. BUEHLER. Rolla, Mo. (1919), 17–20, 42–50, 79, and 96–97.—*Flint clays* have been worked in Mo. for over 50 years and are still being produced over a large area. They form basin shaped deposits and associated with them is a subordinate amount of bond clay resulting from the decomposition of the flint clay. A more recent discovery is *diaspore clay*, an aluminum rich variety, formerly discarded becaues of its sandy texture and tendency to warp when fired. In some cases it is found associated with the flint clay. Although rich in alumina it is poor in silica, lime, and magnesia and appears to be formed of oolites of the mineral diaspore. Besides being added to refractory clays to increase the alumina content it is being used as an ore of aluminum or treated to form an *abrasive*. The deposits are large but have not yet been fully explored. Most of the clay mined in Mo. is *fire-clay* of which some is plastic but much is flint clay. Small amounts of *kaolin*, pottery and brick clays are also mined. The total production in 1917 exceeded that of former years and consisted of 496,694 tons valued at $1,386,338. Of this amount approximately 99% in

weight and 94% in value was fire-clay. Mo. is one of the leading producers of *glass sand*. The sand, which is obtained exclusively from the St. Peter sandstone at a number of places in the state, is remarkably pure, unwashed samples showing 99.14% silica and only 0.078% ion oxide. The Ill. *tripoli* deposits extend south into Mo., for a short distance where they have been worked to a slight extent. An impure *dolomite* is also used as an abrasive, being powdered and used in scouring soap, tooth powder, etc. D. D. S.

35. High grade talc for gas burners. J. S. DILLER, J. G. FAIRCHILD, AND E. S. LARSEN. *Econ. Geol.*, **15,** 665–674 (1920).—Talc is fire and acid proof. Only the very pure homogenous variety is useful for gas burner tips and electric insulators. The annual consumption is less than 1000 tons and since the U. S. is deficient in the high grade material most of it has to be imported from Italy, France, Germany, and India, the Italian and French deposits being the most important. The high grade talc occurs usually in metamorphic limestone but a small amount is found in altered basic igneous rocks while the German deposits form a third type. The only two domestic deposits of commercial size are (1) in Hewitts, Swain Co., North Carolina where the talc occurs as lenses in metamorphic limestone and has been worked but little in recent years; and (2) near Dublin, Harford Co., Maryland, where the talc occurs in an altered dike of basic igneous rock. During the war this was the chief source of supply but the talc is inferior to the imported material. It is quarried in open pits by the Harford Talc Company. The highest grade imported talc comes from Germany. Much of the Italian talc is not massive enough for gas burner tips but it is remarkable for its purity and so is used for toilet powder. French talc comes from the Pyrenees and was the original source of "French chalk." The talc of India is inferior only to that of Germany for gas burner tips, but is not imported directly. A table is given showing the chemical composition of foreign and domestic talcs. All talc used commercially has some admixed chlorite. Too much chlorite causes the burner to crack and shrink due to loss of water, and to darken and become more porous due to the iron content. The texture and grain are of great importance, the German talc having a scarcely perceptible microscopic grain while the others are distinctly grained. D. D. SMYTHE.

36. Flint problems. C. CARUS-WILSON. *Geol. Mag.*, **57,** 474–5 (1920).—A number of English flints are described, and attention is called to problems of their origin. S. G. GORDON. (*C. A.*)

37. High-grade silica materials for glass, refractories, and abrasives. R. J. COLONY. *N. Y. State Museum Bull.*, Nos. **203–4,** 29 pp. (1919).—The siliceous formations exposed in New York State have been studied with a view to det. how far the demand for siliceous materials could be satisfied from these deposits. *Glass sand* suitable for common glass occurs in the region of Oneida Lake in relatively small deposits. *Sandstone* of sufficient purity for glass making and easily crushed, occurs near Johnstown (Potsdam) and at Oris-

kany Falls (Oriskany). *Quartzite* with a firmly interlocking structure and of sufficient purity (95–99% SiO_2) for refractories occurs in large quantities in Duchess County (Ponghquag) and near Accord (Shawangunk). Most of the deposits contain rock suitable for use in the manuf. of ferrisilicon. The harder quartzites (Ponghquag) appear suitable for tube-mill liners. No actual tests were made except a few tests for hardness and toughness. Chem. analyses of the various deposits are given and numerous photomicrographs of thin sections. J. S. LAIRD. (*C. A.*)

38. Measurement of vapor pressures of certain potassium compounds. DANIEL D. JACKSON AND JEROME J. MORGON. Columbia Univ. *J. Ind. Eng. Chem.*, **13**, 110 (1921).—By means of the dynamic method using a current of N_2, the following vapor pressures in mm. of Hg were found: KOH, 8 (795°), KCl, 1.54 (801°), 8.33 (948°), 24.1 (1044°); K_2O, from K_2CO_3, 1.68 (970°), 5.0 (1130°); K_2SO_4, 0.4 (1130°). Up to 1335° the silicates *leucite*, *orthoclase*, and *glauconite* gave no appreciable vapor pressure. The results will be applied to the problem of *potash recovery* from *cement* kiln gases. Ed.

Whiteware and Porcelain

39. Statement to the Color Committee (of A. O. C. S.). I. G. PRIEST. *Cotton Oil Press*, **4**, No. 6, 45–7 (1920).—A brief statement of the elementary ideas on which colorimetry as a science is based including definitions for color, hue, satn., brilliance, light, homogeneous light, transmission, transmittance, and transmissivity. H. S. B. (*C. A.*)

40. Porcelain insulators. O. BOUDOUARD. *Rev. gén. élec.*, **1920**, 681–6; *Science Abstracts*, **23B**, 342.—Tests on 31 samples of American, French and German makers, from various transmission companies are discussed. Six tables give their types and characteristics, chem. analyses, compn. referred to SiO_2 as 100, aspect of fracture and physical appearance, cause of failure, and explanation of defective performance. Compn. varied widely: SiO_2, 63.3 to 74.5%; Al_2O_3, 20.5 to 29.8; CaO, where intentionally present, 1.9 to 4.0; alkalies 3.2 to 6.5; the variations are more striking referred to $SiO_2 = 100$. Defective specimens were high in SiO_2 or CaO. Since quartz is piezo-electric and feldspar liable to electrolysis, substitution should be made with sillimanite, kaolin, alumina or zirconia, and with Al, Mg, Be or alk. silicates, resp. This development has been made by American ceramists, who adhere most closely to Watts' porcelain formula: $RO.4Al_2O_3.16SiO_2$. Close attention to these results appears profitable. F. H. H. (*C. A.*)

41. Factors controlling the design and selection of (porcelain) suspension insulators. W. D. A. PEASLEE. *J. Am. Inst. Elec. Eng.*, **39**, 571–9 (1920).—The factors governing rational porcelain insulator design and insulator shape as affected by the dielec. field of force are discussed. The development of a rationally designed suspension insulator, its proper testing, and its operating

characteristics with a discussion of possible future progress is also described. Curves showing potential distribution, impulse ratio, puncture voltage and flash-over are given. W. E. RUDER. (*C. A.*)

42. Testing (porcelain) insulators in factory and field. LESLIE N. CRICHTON. *Elec. J.*, **17**, 506–10 (1920).—Description of standard methods. C. G. F. (*C. A.*)

43. Surface leakage as a factor in (porcelain) insulator design. T. M. FEDER. *J. Am. Inst. Elec. Eng.*, **39**, 803 (1920). C. G. F. (*C. A.*)

44. Experience with porcelain insulators in America. F. W. PEEK, JR. *Elec. World*, **76**, 1061–4 (1920).—8 illus. A full discussion of tests on and the behavior of porcelain insulators. C. G. F. (*C. A.*)

45. Features of European (porcelain) insulator testing practice. B. SCHAPIRA. *Elec. Rev.*, **77**, 721–4 (1920); 8 illus. C. G. F. (*C. A.*)

46. Some physical properties of white ware glazes. REINHOLD RIEKE. Charlottenburg. *Ber. d. Tech.-wiss. Abt. d. Ver. Keram. Gewerke.*, **5**, Pt. 5, 8–15 (1919).—R. discusses the relative importance of the coef. of expansion, modulus of elasticity, and tensile strength in glazes. Although insufficient data are available, it is likely that elasticity and tensile strength are as important as thermal expansion. While the coef. of exp. of technical porcelain up to 700° is about 35×10^{-7}, that of white ware bodies averages 100×10^{-7}, and a value of $50–100 \times 10^{-7}$ is given for several white ware glazes. The modulus of elasticity for several glazes varies from 5700 to 6800 kg./sq. mm., while the tensile strength is 5–8 kg/sq. mm. The best glaze is one having the highest tensile strength and elasticity, and the same coeff. of exp. as the body. E. N. BUNTING.

47. Sharp fire colors for porcelain. W. FUNK. Meissen. *Ber. deut. Keram. Ges.*, **1**, Pt. 1, 24 (1920).—This article is a general survey of the subject with particular reference to practice as related to hard porcelain. The author discusses the production of the colors blue, yellow, brown, red, black, green and violet; the use of colorless ingredients in the production of colors; the organic materials which are employed as mediums in the application of the colors; and finally, briefly, the various processes for the prepn. of the colors. Brief reference is made to the use of some of the rarer materials, such as neodymium phosphate for violet, tungstic acid with iron and manganese for browns, praseodymium phosphate for light transparent greens, and the doubtful value of neodymium oxide and tungstic acid for underglaze red colors. Only general principles are given, with no formulae or recipes. The paper is an interesting summary but contains no new contribution. C. W. P.

48. Normal colors and harmony of colors. W. OSTWALD. *Keram. Rudn.*, **28**, 447 (1921).—Ostwald's theories are more fully discussed in his book Die Farbenlehre. Leipsig: Verlag Unesma. 259 pp. Outline comment on the fundamentals of his new laws of color which are claimed to systematize the

innumerable color possibilities and permit of classification. Statement by the Director of the Meissen Porcelain Works that they have used O.'s tables for some time for the preparation of harmonic colors successfully.

WM. H. CLARK.

49. Surface creepage and high-voltage (porcelain) insulation. T. NISHI. *J. Am. Inst. Elec. Eng.*, **39**, 949–59 (1920). (*C. A.*)

50. The decoration of porcelain. BANARD, H. *Pottery Gaz.*, **46**, 85–91 (1921).—True oriental porcelain is fired in the first firing only sufficiently to enable it to be handled and the hard firing takes place during the glost firing. In the case of hard porcelain and common stoneware the body and glaze are fired in one operation whereas soft porcelain, china, English bone china, and earthenware undergo two firings. Motor driven polishing lathes are used to remove blemishes from glazed ware due to stilt marks, etc. Underglaze colors when examined under the microscope appear as fine powder. In printing a copper plate is engraved with a pattern which is then covered with an underglaze color. The surplus color is rubbed off. A piece of tissue paper sized with a water size is spread over this plate and the color is pressed onto the paper with a lithographers press. The design is then transferred to the bisque ware which is then passed through a hardening-on kiln where it is fired just sufficient to harden the color. The glaze is then put on and it is fired in a glost kiln. Overglaze colors are a mass of glass with metallic oxides differing from underglaze colors which contain no flux. For enamel colors certain metals may be used. Gold gives a pink and manganese gives an amethyst. Copper with a high soda glass gives turquoise and with a high lead glass, bottle green. The best gold decorations are made by grinding metallic gold with mercury. A flux of glass is used with the gold to make it adhere more firmly. In acid gold decoration the pattern is put on white glazed china with an oily acid resisting paint. The piece is then plunged in an HF bath where all exposed portions are partly etched by the acid. The paint is then removed and gold decorations applied all over the ware. After firing the piece is burnished whereupon the pattern appears bright and the etched portion dull. Ground laying is a process by which an even coating of color is applied on ware in whatever space is desired. For example a green vase with white panels is made as follows: The shape of the panels is painted on with resist. color—anything that will resist oil—which may be a mixture of treacle and color. A very sticky oil, such as boiled linseed, is then applied over the pot. Green enamel is then dusted on, there is just sufficient oil to take a certain amt. of enamel and no more, thus producing an even tone. The pot is then immersed in water which removes the treacle and color but not the oil and enamel.

H. G. SCHURECHT.

Brick and Tile

PATENTS

51. Brick and process of making the same. FRANK ORTH. U. S. 1,363,264, Dec. 28, 1920.—The process for the manufacture of building material which

consists in first preparing an aggregate comprizing particles of substantially pure sillica material in sizes graduated from those of relatively large size to those which will pass a forty mesh screen and of such proportions as to secure a minimum percentage of voids, then mixing therein 2–5% of calcined and hydrated lime, then molding the mixture into the desired shape, then subjecting the material so molded to the action of steam at substantially 125 pounds per square inch for approximately ten hours, and directly thereafter burning the same for a period of substantially eight days at a temperature of 2800–3000°F.

52. Brick-making machine. ARTHUR O. DUPUY. U. S. 1,363,853. Dec. 28, 1920.—The combination of a suitable frame; a plugging mill mounted upon the latter; a suitable die beneath the mill; a pressure chamber located intermediately of the mill and die; a horizontally mounted plunger rod and a plunger connected therewith, the plunger coöperating with the pressure chamber to force the contents of the latter into the die, the plunger including a stepped member; means for shifting the stepped member transversely with reference to the direction of movement of the plunger rod, the means including an elongated bearing rod secured to the stepped member a shaft pivotally mounted upon the frame, an arm fixed to the shaft and provided at its free end with a fork adapted slidably to engage the elongated bearing rod, and means for actuating the shaft; means for feeding the contents of the plugging mill to the pressure chamber; a crank shaft mounted on the frame and connected with the plunger rod; and suitable gearing for actuating the crank shaft.

53. Mold for making tiles. GEORGE W. VOUGHT. U. S. 1,365,753, Jan. 18, 1921.—A mold for shaping hollow tiles comprizing a box having side and end sections, an elastic rubber lining secured to the sections, and a plurality of cores each having an elastic rubber cover arranged in the mold.

54. Brick-mold. ROBERT A. FONTAINE. U. S. 1,361,148, Dec. 7, 1920.—A device comprizing a frame, consisting of parallel side and end angle bars forming a mold, parallel wires connecting the side bars, parallel wires connecting the end bars, means on the bars adjustably supporting the ends of the wires, the means comprizing wedge-shaped blocks having wire receiving slots therein, and cross pieces secured to the wires and located on the inclined upper faces of the wedge blocks.

55. Hollow building-tile. LEE B. GREEN. U. S. 1,365,825, Jan. 18, 1912.—In a hollow building tile which is rectangular in plan, a portion centrally of the tile and four diagonal partitions extending from the different corner portions respectively of the tile toward the central portion and from top to bottom of the tile, the tile having the partitions, upon laying the tile on adjacent portions of two longitudinally alined tiles which correspond with the superposed tile, arranged to extend transversely of and rest on diagonal partitions of the alined tiles.

56. Floor for brick-kilns. HALVER R. STRAIGHT. U. S. 1,364,155, Jan. 4, 1921.—A floor block having its top and bottom substantially parallel and its ends beveled upward and inward, one side being provided with a vertical groove or recess. C. M. SAEGER, JR.

Glass

57. Glass manufacture and the glass sand industry (of Pennsylvania). C. R. PETTKE. *Topographic and Geol. Survey of Penna.*, Rept. **12**, 278 pp. (1919).—P. has made extensive field study of the glass sand deposits and workings in Penna. The more important central deposits are in the Orishany sandstone, the western in the Pottsville. The Tuscarora sandstone is a hard quartzite which can not be economically crushed to glass sand. The Oriskany deposits are believed to have been derived from the Tuscarora and their purity is attributed to this origin. They are often very pure but in all cases washing is necessary to produce No. 1 sand. Only weathered portions of the deposits are workable, the unweathered being hard quartzite. The report is extensively illustrated and includes a detailed description of glass manuf. including the more recent developments, such as machine-blown glass. J. S. LAIRD.

58. Colored glass. K. WARGA. Brit. 148,304, July 9, 1920.—Colored designs are formed on glass surfaces by fusing the colors on at one operation. The designs are formed of fusible mineral colors and are built up in successive layers on transfer paper. The complete design is then transferred to the glass surface and fired at a gradually increasing temp. until it is completely fused on. The layers are composed of materials which melt at successive temps., the layer next the glass melting first and the outer layer last. The temp. at which the last layer melts is about 100° below the m. p. of the glass. (*C. A.*)

59. Glass, enamels, and glazes. E. REITZ. Brit. 148,816, July 10, 1920.—Relates to the manuf. of white clouded glass, enamels, and glazes. Fluorides are used in conjunction with compds. of Zr, Sn, Be, etc. Alkali fluorides, alkali silicofluorides, CaF_2, and cryolite are stated to be suitable compds. for use. A frit, given as an example, consists of Na_2CO_3, feldspar, quartz, natural zirconia and sodium silicofluorides. The F. compds. are used in larger proportions than has hitherto been done. The batches must contain a large proportion of SiO_2. (*C. A.*)

60. The devitrification of glass. A surface phenomenon. The repair of crystallized glass apparatus. ALBERT F. O. GERMANN. Western Reserve Univ. *J. Amer. Chem. Soc.*, **43**, 11–14 (1921).—Due to the hydrolytic action of adsorbed moisture, the surface of weathered glass contains silicic acid and also alkali and alkaline earth carbonates. Washing removes the carbonates. Heating dehydrates the silicic acid and gives a rough surface. The sepd. silica may gradually dissolve in the underlying glass or may unite with the

lime forming a difficultly fusible cryst. Ca silicate over the surface. Weathered glass which devitrifies and becomes brittle when worked in the flame can be made practically as good as new glass, if the devitrified surface layer be removed by washing with dil. HF before heating the glass in the flame. Ed.

61. Composition of Golden Yellow Glass. *Schnurpfeil's Review for Glass Works*, **4**, 745 (1921).—Sand 100, potash 10, soda ash 30, lime 17, millet 2.5, bark 0.75. R. J. MONTGOMERY.

62. Opal Glass for Tubing. *Schnurpfeil's Review for Glass Works*, **4**, 747 (1921).—Sand 100, soda ash 38, lime 10, alumina 6, feldspar 15, fluorspar 13, lime oxide 2. R. J. MONTGOMERY.

63. Absorption of heat in glass. A. Q. TOOL AND C. G. EICHLIN. *J. Optical Soc. Am.* **4**, 340–63 (1920); cf. *C. A.*, **14**, 2245.—A marked increase in the absorption of heat by glass heated at a uniform rate takes place within a narrow temp. range slightly above the annealing temp. The authors suggest as the cause of the formation of one or more types of mol. aggregates possibly of cryst. structure. Tests on chilled and annealed glass produce the results expected from this theory and also lead to the possibility, "that *annealing* is not alone a question of removing stresses, but also of producing homogeneity." The results of various tests on 20 types of glass are tabulated.

DONALD E. SHARP (C. A.)

64. Making of aventurine glass. *Schnurpfeil's Review for Glass Works*. **4**, 723 (1920).—Copper aventurine is a reddish brown, gold-spangled composition while chrome aventurine is greenish brown, gold-spangled. Melting procedure is as follows: After melting in an open pot, it is often covered with a lid and kept in the furnace for a certain time thus closed. The whole pot is then placed in a hot annealing furnace and cooled slowly allowing the copper and chrome crystals to form. Batch for red aventurine: Sand 100, soda ash 40, lime 15, lead 5, borax 5, oxide of tin 2, ferrous oxide 4, red oxide of copper 8.5 Green aventurine: Sand 100, soda ash 36, lime 14, fluorspar 2, barytes 14, potassium bichromate 9.5. ROBERT J. MONTGOMERY.

65. Composition of selenium red glass. *Schnurpfeil's Review for Glass Works*, **4**, 725 (1920).—Sand 100, soda ash 35, lime 20, fluorspar 1, selenium 0.5, arsenic 1.5. ROBERT J. MONTGOMERY.

66. A new electrical precipitation treater. (The electrical conductivity of glass). M. SHIBUSAWA AND Y. NIWA. Electrotechnical Laboratory, Tokyo. *J. Am. Inst. Elec. Eng.*, **39**, 890–903 (1920).—The new precipitation treater for the Cottrell process consists of a metal tube as the passive electrode and a *glass covered* coaxial wire as the active electrode. Since it became evident from the action of the new treater that a current was passing through the glass, the authors investigated the *variation of the resistivity of glass with temperature*. A soda lime glass tube filled with mercury, wrapped with tinfoil

and supplied with guard rings to prevent surface leakage was used. For applied voltages below 500 volts the resistivity, $\overline{R}$, between 20° and 80°C was found to be $3.28 \times 10^9 \times t^{-3.25}$ and for an applied voltage of 10,000, $2.06 \times 10^9 \times t^{-3.25}$ megohms. *Effect of potential gradient.* The relation found was $\overline{R} = 2.9 \times 10^9 \times V^{-2.60}$ megohms, where V is in *kv*; room temperature. The soda-lime glass showed hysterisis while Jena glass showed none. Ed.

67. The permeability of glass to iodine and bromine vapours. JAMES BRIERLEY FIRTH. *Jour. Chem. Soc. Lond.*, **117**, 1602–3 (1920).—Iodine and bromine do not diffuse through glass under ordinary experimental conditions. Only in extreme cases is there a possibility of such diffusion. After a period of nine and one-half years, iodine was found to have passed through a glass bulb 0.208 mm. thick. The bulb was heated to 360°C for 100 days during the experiment. In this experiment the bulb was placed in a large tube and both tube and bulb evacuated. In another case, in which iodine was found to pass through 0.211 mm. of glass, there was a vacuum outside of the bulb and atmospheric pressure inside. There was no evidence of bromine passing through a similar thickness of glass after nine and one-half years. J. L. C.

PATENTS

68. Glass stirring machine. CHARLES R. HAZEL. U. S. 1,361,853, Dec. 14, 1920.—In combination a supporting frame for glass cylinders, a plurality of arms spaced along the frame and extending transversely thereof, and a flexible equalizing means extending longitudinally of the frame and supporting the series of arms.

69. Glass and its manufacture. LOUIS E. BARTEN. U. S. 1,362,917, Dec. 21, 1920.—As a new article of manufacture, normally detached glass-ware of definitely predetermined configuration, and consisting of a throughout uniform, homogeneous, mass of uniformly-light-effected glass containing not less than 25 per cent, of titanic oxid.

70. Glass annealing leer. EDWIN E. MILNER. U. S. 1,361,604, Dec. 7, 1920.—An annealing furnace comprizing a plurality of groups of chamber heating flues surrounding the major portion of the annealing chamber in which the articles are to be annealed, one group of the chamber heating flues having means for circulating a heating medium therethrough in opposite directions in adjacent flues, and another group of the chamber heating flues having means for circulating a heating medium upwardly in the same direction in adjacent flues at opposite sides of the annealing chamber, substantially as described.

71. Machine for casting plate-glass. HARRY O. BISBING. U. S. 1,363,450, Dec. 28, 1920.—A reservoir adapted to contain molten glass, a discharge passageway leading from the reservoir, a chain-like series of platens adapted to receive glass from such discharge passageway, means for bringing each platen in place to receive glass, a flap valve closing the discharge passageway opened

by each platen successively as the same is brought into receiving position, means for closing the flap valve after such platen has passed from its receiving position, and a tamping plate adapted to be brought into contact with the glass carried in each platen, leveling and smoothing the same.

72. Glass-handling apparatus. THEODORE C. STEIMER. U. S. 1,362,756, Dec. 21, 1920.—A machine for treating glass articles, with continuously traveling article handling mechanism, of a fixed station, a transfer mechanism movable with and in respect to the article-handling mechanism, device for moving the transfer mechanism to and holding it at the fixed station and moving it with the article-holding mechanism and in coöperative relation therewith and device for effecting a transfer of articles between the transfer mechanism and the station while the transfer mechanism is stationary.

73. Process of obtaining mold charges of glass and apparatus therefor. ENOCH T. FERNGREN. U. S. 1,362,785, Dec. 21, 1920.—The process of obtaining glass mold charges which consists in causing glass to issue from a suitable outlet, and while moving under gravity to sever into charges and imparting to the severing means, while severing, a movement having a component in the direction of the movement of the glass at the severing point.

74. Glass-drawing process. HARRY G. SLINGLUFF. U. S. 1,364,895, Jan. 11, 1921.—The process of drawing a glass sheet from a relatively large deep body of molten glass, which consists in segregating the layer of glass beneath the line of generation of the sheet from the main body of glass there beneath and drawing the sheet upward with such line of generation remote laterally in both directions from any anchoring or chilling body of clay or refractory material in the body of glass.

75. Apparatus for drawing glass cylinders. ARTHUR E. SPINASSE. U. S. 1,361,635, Dec. 7, 1920.—In combination, a bait, a drawing drum connected to the bait, a motor for driving the drum, an air conduit connected to the bait, a blower for supplying air to the conduit, and means whereby the blower may be connected to and driven by the motor.

76. Process for manufacture of white clouded glasses, enamels, and glazes. EDUARD RIETZ. U. S. 1,366,101, Jan. 18, 1921.—The process which comprizes the embodying unpurified clouding material in the glass, glaze or enamel with material containing sufficient fluorin to prevent discoloring.

77. Machine for burning or glazing the edges and sides of glassware. ALBERT BREAKENRIDGE KNIGHT. U. S. 1,364,939, Jan. 11, 1921.—A device of this type having a rotatable gear, a gear fixed against rotation mounted above the rotatable gear coaxial therewith; means for simultaneously vertically adjusting the gears, spindle journals secured to the rotatable gear, rotatable spindles mounted in the journals, pinions on the spindles meshing with the gear fixed against rotation, and rollers rotatably carried by the spindle journals and engaging the upper surface of the last named gear.

78. Machine for grinding glassware. ALBERT BREAKENRIDGE KNIGHT, U. S. 1,364,940, Jan. 11, 1921.—An apparatus for grinding glassware with a support, a plurality of elements for holding and rotating grinding members, a plurality of chucks for receiving the articles to be ground and connected with the support to be moved toward and away from the grinding members, with means to successively move the chucks in one direction, embodying treadle levers corresponding in number and arrangement to the chucks, and a system of levers connecting each of the treadle levers and its corresponding chuck.

79. Glass gathering and shaping machine. MICHAEL J. OWENS. U. S. 1,364,514, Jan. 4, 1921.—The combination of a gathering device, a press plunger, a press mold, means to relatively reciprocate the plunger and mold to and from each other, and means to introduce the gathering device between the plunger and mold while they are separated and discharge a gather into the mold.

80. Glass. MAURICE A. SMITH. U. S. 1,365,797, Jan. 18, 1921.—A glass having a low coefficient of expansion and high resistance to high and low temperatures, the glass being made from a batch consisting of a prepondrance of silica, smaller amounts of boric oxid, alumina, sodium nitrate and sodium carbonate, and still smaller amounts of calcium carbonate and arsenic trioxid.

C. W. SAEGER, JR.

Enamel

81. Gas in the enameling industry. J. H. GUMZ. *Gas Record*, Dec. 22, 1920.—Reprinted by Surface Combustion Co., New York. Vitreous enamels are differentiated from japan varnishes and a historical sketch of the industry is given together with a brief description of the enameling process. The author emphasizes the necessity of a muffle type furnace with coal as fuel, or even with gas or oil when the surface combustion or intermittent firing plan is not used. Cross section views of the various types of furnaces are shown. The muffle type furnace especially where coal is the fuel, shows highest construction and repair costs and requires the most floor space. Firing costs of the various types of furnaces are as follows per cu. ft. of oven space heated per hr.:

Type of Furnace	Cost per hour Without Recuperation	Cost per hour With Recuperation
Direct fired gas	1.0 cent	0.8
Semi muffle gas	1.4	1.1
Oil fired (prob. muffle type)	1.5	1.2
Full muffle gas	1.6	1.2
Coal fired muffle	1.7	1.3
Electric direct	...	1.4

Further savings result from applying flue gases in waste heat boilers and dry rooms. Some of the advantages claimed for the direct fired gas furnace are: (1) lower operating costs; (2) low construction costs because muffles,

stacks and excessive insulation are not required; (3) low repair costs; (4) elimination of coal and oil storage and fireman; (5) uniform heating and larger percentage of furnace available for firing ware; (6) absolute control and ability to rapidly change furnace temp. as required; (7) increased output considering time lost during repairs and the higher temp. possible. R. R. DANIELSON.

PATENTS

82. Enameling resistance units. LEONARD KEBLER. U. S. 1,361,869, Dec. 14, 1920.—The method of enameling tubular units which consist in applying enamel material on them, and heating them electrically from within.

83. Process for producing a single white-enamel coat on steel. SIMON RIESSER. U. S. 1,360,317, Nov. 30, 1920.—In the treatment of frit in the production of white enamel on steel, the process of grinding the frit with water and clay and removing a portion only of the soluble enameling constituents.

84. Process for making enamels. GEORGE RUPPRECHT. U. S. 1,360,585, Nov. 30, 1920.—The process consists in subjecting the raw materials to the direct action of a flame developing a high temperature under conditions which prevent the material melted thereby from coming in contact with foreign substances and supporting the molten material upon an unmolten mass of the raw materials. C. M. SAEGER, JR.

Cement, Lime and Plaster

85. Molding, gypsum cement, etc. A. HAENICKE. Brit. 148,797, July 10, 1920.—In the production of small shaped articles, *e. g.*, buttons, from gypsum, cement, etc., the finely ground material is pressed in a dry state, the pressed article is removed from the mold and subjected to a spray of H_2O or setting liquid until just sufficient liquid for setting has been absorbed. Burnt magnesite may be employed, a lye of $MgCl_2$ being employed as a setting liquid. (*C. A.*)

86. Further discussion of "Cal." S. W. STRATTON. *Concrete* (*Mill Sec.*), **17**, 125 (1920).—Cal is obtained by grinding the dried or undried product resulting from a mixt. of either quicklime or hydrated lime, $CaCl_2$ and H_2O. It can be used to advantage to hasten the set of portland cement. Five % of cal added to a cement mortar increases the strength test at 2 days from 40 to 140%. It has the advantage over $CaCl_2$ in that it is less hydroscopic and can therefore be more easily handled. J. A. MONTGOMERY. (*C. A.*)

BOOKS

87. MÜLLER. **Der Schachtofen in der Zementindustrie.** Charlottenburg: Zementverlag G. m. b. H. 68 pp. M. 5.50. For review see *Tonind.-Ztg.*, **44**, 1073 (1920). (*C. A.*)

88. BLOCK, BERTHOLD. **Das Kalkbrennen im Schachtofen mit Mischfeurung.** Otto Spamer, Leipzig. 240 pp. For review see *J. Fabr. Sucre*, **61**, No. 34. (C. A.)

ACTIVITIES OF THE SOCIETY

Annual Meeting of New England Section

The Annual Meeting was held at Boston, January 22, 1921. Thirteen members attended.

In the afternoon, the Agassiz Museum at Harvard University was visited. One of the most interesting things observed was the exhibit of glass flowers.

A dinner was served at the Engineers Club at 5 P.M., which was followed by a short business session. The following officers were elected for the ensuing year:

Chairman, A. T. Malm.
Councillor, M. C. Booze
Secretary and Treasurer, S. F. Walton.
Executive Committee, Browne Harding, Prof. C. L. Norton.

The following talks were given:

"Some Troubles Encountered in the Manufacture of Watch Dials," by F. P. Flagg, Chief Chemist, Waltham Watch Co.

"Notes on Efficiency of Clay Crucibles," by H. W. Richter of Garhart Dental Specialty Co.

"A Novel Testing Furnace," by S. F. Walton, Kalmus, Comstock & Wescott Co.

"Application of Pyrometers to Ceramic Industries," by H. Goldsen, General Sales Manager, Wilson-Maeulen Co.

The talks were interesting and a lively discussion followed.

M. C. BOOZE,
Secretary New England Section

JOURNAL AMERICAN CERAMIC SOCIETY

Preparation of Abstracts

Every article in THIS JOURNAL is to be preceded by an abstract prepared by the author and submitted by him with the manuscript. The abstract is intended to serve as an aid to the reader by furnishing an index and brief summary or preliminary survey of the contents of the article; it should be suitable for reprinting in an abstract journal so as to make a reabstracting of the article unnecessary. The abstract should, therefore, **summarize all new information completely and precisely.** Furthermore, in order to enable a reader to tell at a glance what the article is about and to enable an efficient index of its subject matter to be readily prepared, the abstract should contain **a set of subtitles** which together form a **complete and precise** index of the information contained in the article. This requires at least one and often several subtitles even for a short abstract.

In the preparation of abstracts, authors should be guided by the following rules, which are illustrated by the abstracts in THIS JOURNAL for February and March, 1921.* The **new information** contained in an article should first be determined by a careful analysis; then the subtitles should be formulated; and finally the text should be written and checked.

Rules

1. **Material not new** need not be analyzed or described in detail; a valuable summary of a previous work, however, should be noted with a statement indicating its nature and scope.

2. **The subtitles should together include all the new information;** that is every measurement, observation, method, improvement, suggestion and theory which is presented by the author as new and of value in itself.

3. **Each subtitle should describe the corresponding information so precisely** that the chance of any investigator being misled into thinking the article contains the particular information he desires when it does not, or vice-versa, may be small Such a title as "A note on blue glass," for example, is evidently too indefinite a description of information regarding "Absorption spectra of glass containing various amounts of copper-cobalt and chromium-cobalt." General subtitles, such as "Purpose" and "Results" should not be employed as they do not help to describe the specific information given in the article.

4. **The text should summarize the authors' conclusions and should transcribe numerical results of general interest,** including those that might be looked for in a table of physical and chemical constants, with an indication of the accuracy of each. It should give all the information that anyone, not a specialist in the particular field involved, might care to have in his note book.

5. **The text should be divided into as many paragraphs as** there are distinct subjects concerning which information is given, but no more than necessary. All parts of subtitles may be scattered through the text but the subject of each paragraph, however short, must be indicated at the beginning.

6. **Complete sentences** should be used except in the case of subtitles. The abstract should be made as readable as the necessary brevity will permit.

7. The ms. of all abstracts must be typewritten and double or triple spaced.

* The rules were prepared by the Research Information Service of the National Research Council. The Society is indebted to Dr. G. S. Fulcher of the Corning Glass Works (formerly with the National Research Council) for the rules and the illustrative abstracts.

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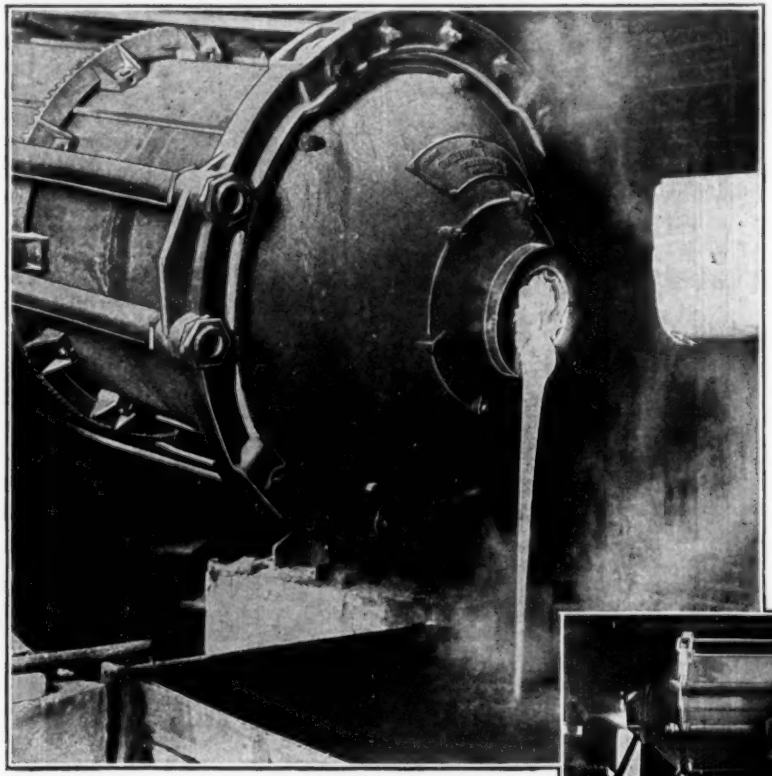

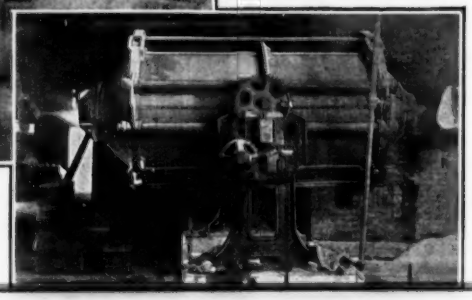

These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

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Ingram-Richardson Mfg. Company claim those remarkable results for their U. S. Enamel Furnaces. With four U. S. Furnaces operating at their plants at Frankfort, Indiana, and Beaver Falls, Pa., they are saving thousands of dollars yearly in fuel and labor.

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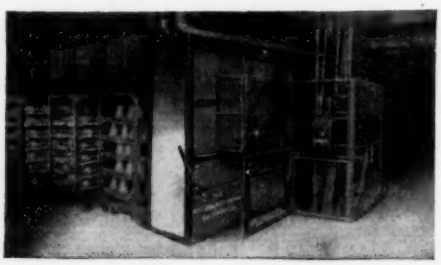
For High Tension Electrical Insulators

Cut a week from the Manufacturing Schedule



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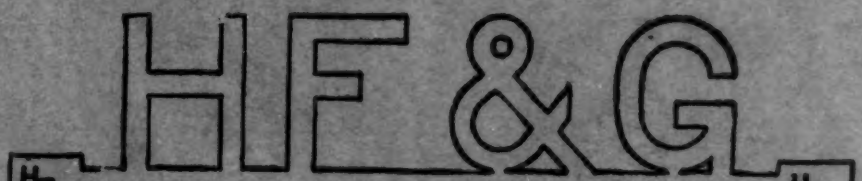

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